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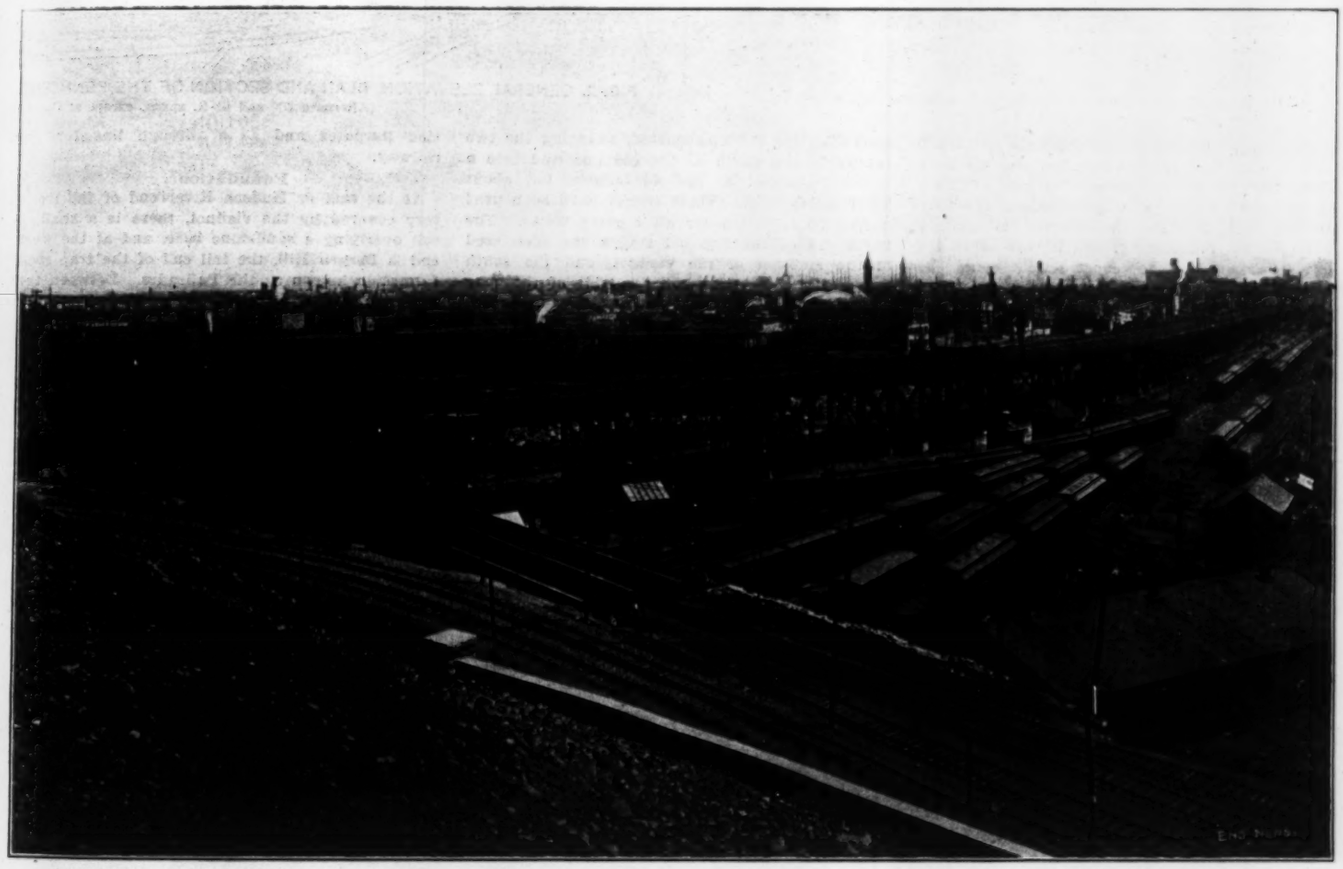


VIEW OF THE PENHORN CREEK VIADUCT OF THE ERIE R. R. LOOKING EAST TOWARD JERSEY CITY.

[Photograph by F. D. Pangborn.]

The Penhorn Creek Viaduct of the Erie Railroad.

For the past three years the Erie R. R. has been changing its line through Bergen Hill, about a mile west of its Hudson River terminus at Jersey City, from a two-track tunnel to a four-track open cut with occasional short tunnels at street crossings (Engineering News, Feb. 21, 1907, p. 204). The old tunnel was but slightly higher in elevation than the terminal station and was reached from the latter by tracks elevated through the streets of Jersey City but running down to tunnel level about 500 ft. east of the tunnel portal. On account of certain considerations of economy in freight operation and in construction it was decided to fix the elevation of the new cut at its easterly end some 40 ft. above the old tunnel and to bring the tracks down to the grade of the elevated structure in the city on a four-track viaduct. This viaduct, known as the Penhorn Creek viaduct, extends from the portal of the cut 2,550 ft. east, making a change in elevation of 22.6 ft. on 1 and 1¼% grades. The easterly 754 ft. is on a timber trestle founded on the retained fill forming a part of the old elevated structure in the city. This will be filled in later. The remaining 1776 ft. is on an extremely heavy steel structure. The work started about a year ago and it has recently been completed. The new cut is immediately alongside the old tunnel, so that the viaduct is about over the old main line tracks of the railway, on which a very heavy and congested through and commuting traffic had to be maintained during construction. On account of this and also because of unexpected difficulties with some of the foundations, the work has a great interest aside from its normal importance as a heavy piece of steelwork.

The view on this page shows the completed viaduct looking from Bergen Hill near the east end of the cut east toward Jersey City. Fig. 2 shows the general lay-out of the viaduct from the west end of the timber trestle (later to be filled) at Coles St. to the portal of the cut. With the exception of the two 66-ft. crossings at Monmouth and Coles Sts., respectively, it consists of alternate 30- and 61-ft. plate-girder spans, supported on transverse girders which in turn rest on three (in one place, four) columns, footing on concrete pedestals. The columns are spaced laterally to suit the conditions of various tracks crossing beneath the viaduct.

On the old alinement both freight and passenger trains were run through the tunnel, the latter continuing on the main tracks to the terminal, the former switching either to north or south to the freight terminals on each side of the passenger station. In the new plans the four-track line will be used only for passengers, and the

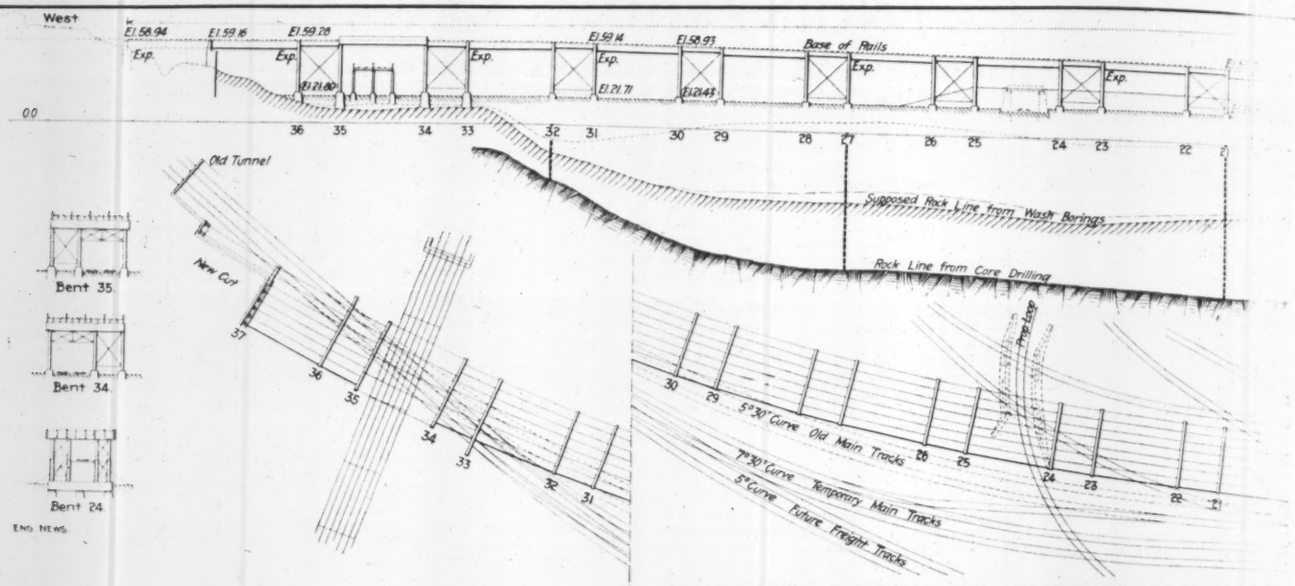


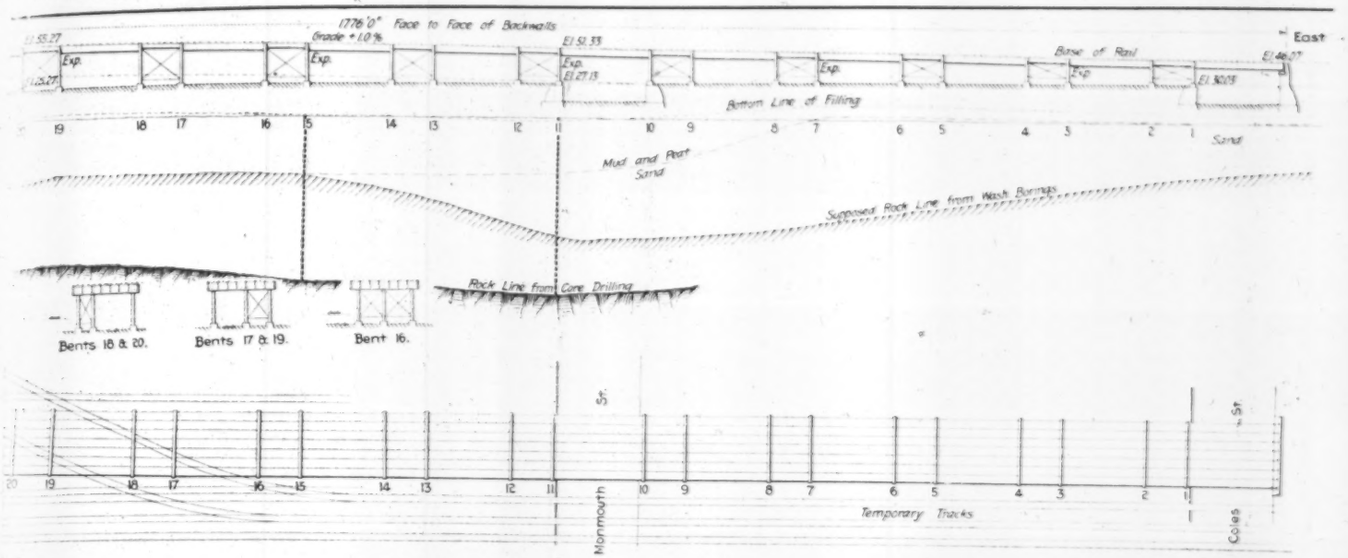
FIG. 2. GENERAL ELEVATION, PLAN AND SECTION OF THE PENHORN
(Alternate 30- and 61-ft. spans, except at Coles

freight trains will still run through the two-track tunnel taking the same switch on the north to tracks later to be elevated over streets, but taking the south tracks at a point nearer the tunnel (see Fig. 2). As the viaduct is directly above the old main-line tracks it was necessary to shift them before construction could be started. At a point some 200 ft. east of the portal of the old tunnel a curve of larger degree than the old was started, swinging the two tracks to the south of the old line and into a tangent, parallel to the old tangent but about 25 ft. south of it. These tracks have been used during construction for all regular traffic. The north one of the two old tracks has been used in the erection of the viaduct, and the south one of the old tracks, being outside of the zone of the viaduct, has been used both for construction purposes and as a through line for the railway.

Foundations.

At the east or Hudson River end of the territory covered by the viaduct, there is a shallow soil overlying a sandstone base, and at the west end is Bergen Hill, the tail end of the trap rock formation known as the Palisades. Between the two there is a water-soaked sand and gravel,

FIG. 3. VIEW OF THE VIADUCT LOOKING WEST FROM TRESTLE APPROACH TOWARD TUNNEL AND OPEN CUT THROUGH BERGEN HILL.



CREEK VIADUCT OF THE ERIE RAILROAD, NEAR JERSEY CITY, N. J.
and Monmouth St., where there are 66-ft. spans.)

covering, at a variable but considerable depth, a pronounced dip in the same sandstone formation that is found farther east. It is on this water-soaked ground that the greater part of the viaduct is built. In the construction of the old line of the Erie through this district some records were obtained of the nature of the ground, but only enough to cause the engineers to have a new set of borings made on the line of the new construction. These borings were made, under contract, with a wash drill, and the nature of the ground reported by the contractor is shown as the "Supposed Rock Line from Wash Borings" in the section on Fig. 2. This indicates a surface filling of mud, peat and sand over a varying surface of hard rock. It will be seen that at the east end of the viaduct, from Monmouth to Coles Sts., the mud and peat is comparatively shallow and the sand comprises most of the material overlying the rock. From Monmouth St. westward, however, there is no sand to speak of but only the weak mud filling. In view of these conditions, as revealed by the test borings and testified to by the experience of the engineers familiar with the ground, it was decided to found the pedestals of the eastern part of the viaduct on concrete piles driven to refusal, trusting to the sand to give sufficient lateral support. West of Monmouth St., on account of the lack of lateral support, each pedestal was to be footed on hollow concrete caissons, some 6 ft. in diameter, sunk in free air to rock or other suitable bearing and filled with concrete. At the far eastern end of the viaduct the timber trestle was to be founded on wooden sills.

The construction was started and the wooden trestle and concrete pile footings were completed as designed. In the sinking of the concrete caissons it was found that the rock surface as reported by the wash borings was very inaccurate. One cylinder reached the point marked "rock elevation" on an adjacent wash boring with no indication whatsoever of any rock. Its sinking was continued for 20 ft. without rock being reached. The next cylinder showed the boring rock-level 15 ft. too high, and the presence of a number of large boulders convinced the engineers that these smaller stones had been mistaken for solid rock. Core drills were then set up at Bents, 11, 15, 21, 27 and 32, and a new set of borings made which showed that something had been radically wrong with the wash-borings previously reported.

As shown in the sections of these core drill borings on Fig. 4, the rock line as assumed in the original plans was from 15 to 20 ft. too high. This complicated the use of the caissons or open cylinders, but nevertheless their use was continued as described below.

OLD FOOTINGS.—As stated above, the raised elevation of the old main line tracks was carried to grade at a point about 300 ft. west of Monmouth St. on an earth fill retained by masonry walls and by abutments for the girders at street crossings. The north retaining wall of this fill is in line with the north line of columns of the new viaduct and the abutments at street crossings are about at the same places as the new abutments. Consequently these old footings were used to some extent in the new work. In this article the term "ground level," when applied to that part of the structure between Coles St. and Bent 15, means the surface of the old fill which varies from about 12 ft. to zero above the adjoining street levels.

About 1893 the Erie R. R. proposed to make numerous changes in the approach to its Jersey City terminal, and started construction on a new viaduct at this place. The work only progressed as far as the foundations when it was stopped, and these footings have been in place ever since. In some cases they have been utilized in the present work, as noted hereafter.

CONCRETE PILE FOOTINGS.—Bents 2 to 9 (Fig. 5) rest on stepped concrete pedestals footing on clusters of concrete piles, increasing in number toward the more treacherous ground to the west. The average load per pile is about 19 tons. The pedestals are three to each bent and, in this portion of the viaduct, spaced a uniform distance of 20 ft. apart, transversely. The south and middle lines foot entirely on the piles, but under the north line the footings of the old retaining wall are utilized, as described hereinafter.

The concrete piles used here were 16 × 16 ins. square at the top and 8 × 8 ins. square at the point, with length varying from 38 to 65 ft. in length, but averaging 52 ft. for the 256 used. They were reinforced by ¾-in. rods at each corner and ½-in. rods in the middle of each face, tied together by ¼-in. loop rods spaced 3 ins. c. to c. for the top and bottom 3 ft. 6 ins. c. to c. for the next 3 ft. top and bottom, and 12 ins. c. to c. in the middle of the pile. They were molded on the ground of 1:2:4 concrete and allowed to set 30 days before being driven in place. Most of the piles were driven with a steam-hammer to a refusal of 150 blows in 12 ins., with the aid of a water jet. In some instances a 3,000-lb. drop-hammer was used. The driving in all cases was in a hard sand which offered great resistance to penetration. In fact, on an average only two piles per 8-hr. day could be driven with one pile-driver.

Along the north line of the columns for some 700 ft. west of Coles St. was the old masonry retaining wall founded on wooden piles. The footings to this wall were utilized in the foundations of the north line of pedestals in Bents 2 to 9, as shown at the left in Fig. 5. On each side of the masonry wall three concrete piles were driven to refusal and capped longitudinally with three old rails. Upon these rails as a grillage, three cross-girders 3 ft. 3 ins. deep were set and the whole construction covered with concrete to a depth of about 6 ft. below ground level, forming a base 10 ft. × 11 ft. 6 ins. in area, upon which to rest the pedestal. On the north or

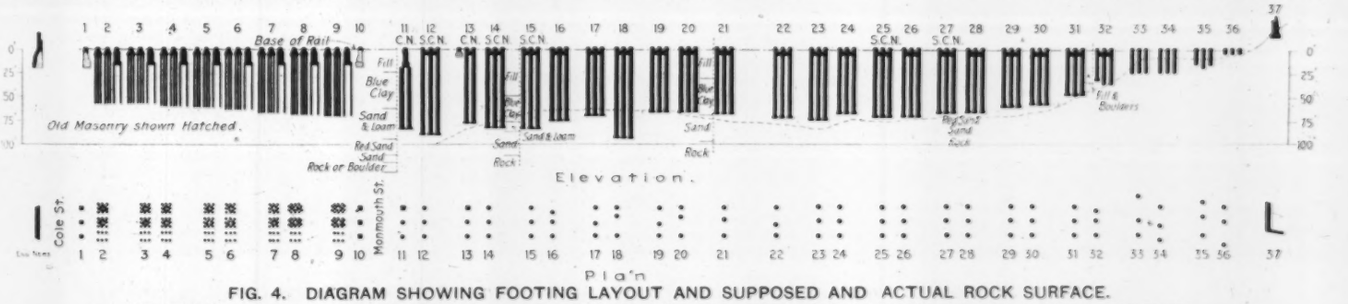


FIG. 4. DIAGRAM SHOWING FOOTING LAYOUT AND SUPPOSED AND ACTUAL ROCK SURFACE.
(Dotted line represents supposed rock surface as determined by wash borings. Individual core borings shown at locations where taken.)

street side the wall was left intact holding back the old fill. Thus, on the north line of Bents 2 to 9, only 6 concrete piles were used as compared with 12 or 16 on the other two lines. The steel beams and rails used here were to some extent old material, and their cost did not equal the cost of the extra concrete piles.

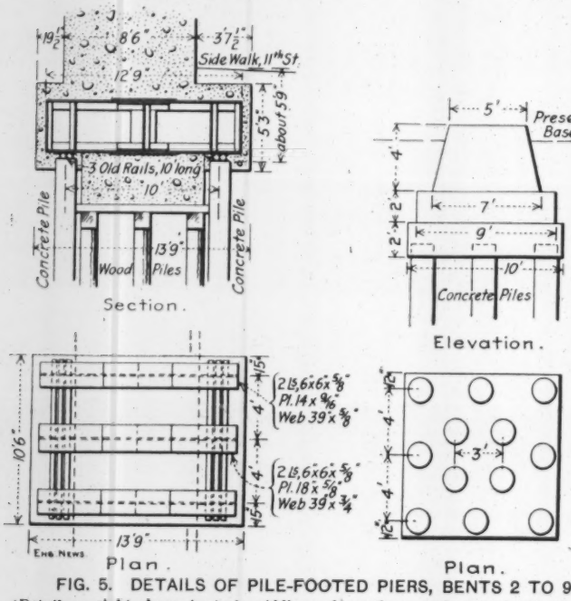


FIG. 5. DETAILS OF PILE-FOOTED PIERS, BENTS 2 TO 9.

(Detail on right shows typical middle and southern pedestal; detail on left is typical northern pedestal where old retaining wall footings were utilized.)

In the abutments on either side of Coles St. and on the east side of Monmouth St. the old abutments were used, raising the bridge seats to the proper elevation by concrete walls for the whole width of the abutment on the east side of Coles St. and by separate pedestals at the two other bents.

CONCRETE CAISSONS OR CYLINDERS.—West of Monmouth St. most of the pedestals are founded on concrete caissons or hollow cylinders sunk in free air and filled with concrete. On account of the great depth of mud and sand shown in the first wash borings it was thought that there was not enough lateral support to warrant the use of piles, and the cost of compressed-air caissons being too high, the open-air concrete cylinder of large enough section to ensure its rigidity was designed. One of each of these cylinders was to be sunk under each pedestal, which on account of the numerous tracks crossing under the viaduct were spaced at varying distances transversely as shown on Fig. 2.

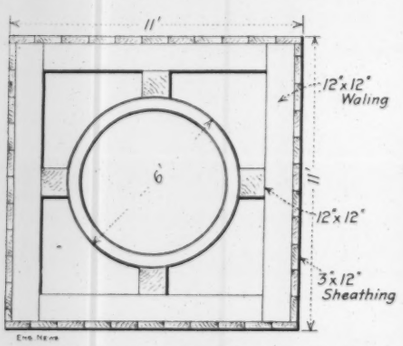


Fig. 6. Detail of Excavation for Concrete Caissons.

Each caisson was to consist of a hollow concrete cylinder, 6 ft. 6 ins. in outside diameter and 4 ft. 6 ins. inside, reinforced with ½-in. vertical rods, 9 ins. c. to c., and ½-in. horizontal rods, 6 ins. c. to c., the vertical rods located 2 ins. from the exterior face of the concrete and the horizontal rods immediately inside of them.

These caissons were to be sunk by jetting and, if necessary, loading, adding the concrete on the top as a continuous part of the cylinder as the caisson descended and excavating the interior with grab buckets. It was hoped that each caisson would reach solid rock, and then the interior would be filled with concrete, making a solid concrete pillar from the rock to the base of the pedestal. However, as noted above, the supposed rock bottom was found to be a considerable distance below that marked on the drawings from which the estimates were made, such an extra distance, in fact, that to reach it would require more time than could be allowed.

Under the original scheme the cylinder footings were assumed to be able to care for a maximum of 10.8 tons per sq. ft. if bearing directly on the rock. From an investigation of the sand which overlay the rock it was decided that it would safely stand a maximum load of 7 tons per sq. ft. Thus, for the same loads on the cylinders, a bottom area about 1½ times as large would be required, if the sand was used as a footing; that is, instead of the 6.5 ft. diameter at the bottom, a diameter of 8 ft. would furnish ample area for a safe loading of the sand. It was then decided to bell out the bottom so as to get a diameter of 8 ft. and to foot that bell on hard sand. This reduced the bearing value at the bottom as shown in the accompanying table.

PENHORN CREEK VIADUCT—BEARINGS FOR CAISSONS.

	Total wt. in net tons, exclusive of caisson weights.			Tons per sq. ft. 6′ 6″ dia.			Tons per sq. ft. 8′ dia.		
	North.	Center.	South.	North.	Center.	South.	North.	Center.	South.
Bents 12 to 15	227	227	227	6.83	6.83	6.83	4.50	4.50	4.50
Bent 16	227	199	342½	6.83	6.00	10.38	4.50	3.97	6.85
Bents 17 and 19	205½	301	249	6.18	9.06	7.50	4.08	5.96	4.94
Bents 18 and 20	269	229½	274½	8.15	6.92	8.27	5.38	4.56	5.45
Bent 21	245	237	274½	7.37	7.15	8.27	4.86	4.72	5.45
Bent 22	203	304½	248	6.12	9.17	7.47	4.03	6.05	4.93
Bent 23	261	285	261	7.83	8.57	7.83	5.17	5.66	5.17
Bent 24	295	201½	308	8.88	6.06	9.28	5.86	4.00	6.12
Bents 25 to 31	261	261	261	7.83	7.83	7.83	5.17	5.17	5.17
Bent 32	227	229½	358	6.82	6.91	10.78	4.52	4.55	7.12

Acting on the experiments of the Pennsylvania R. R. in its East River tunnels, and on local tests, it was decided to consider the skin-friction of the caissons sufficient to take their own weight, so that the loads given in this table do not include the weight of the solid cylinder from bottom to ground level.

The concrete caissons, of the dimensions noted above, were built in place at each location. First, a square pit about 11 ft. square and 10 ft. deep was dug and sheathed with 3-in. butt sheathing held by 12 × 12-in. horizontal waling pieces. Then at the middle of each side a 12 × 12-in. stick was set vertically (as shown in the plan in Fig. 6) as the guide for the caisson during the sinking. These vertical timbers were the only guides used, and served their purpose admirably. At the bottom of the pit there was then set the cast-iron cutting edge shown also in Fig. 7. The reinforcement was then placed, and around it was set a 5-ft. length of cylindrical sheet-iron (in two pieces so as to be removable) for an outside form. The inside form was a 5-ft. length of collapsible steel framing braced by radial struts.

Each caisson was cast in a 20-ft. unit before being sunk; this 20-ft. length took four sets of the steel forming or two movements of a double set, shifting from bottom to top on successive days. For each 20-ft. length about one day was consumed in laying concrete, one day in moving forms and four days in setting, before the sinking was commenced. At the end of the six days, then, the cylinder was sunk until it was about a foot above the bottom of the pit, and the process repeated. Necessarily, with work going on on several cylinders at once, no time was lost by the sinking gang.

When the concrete in a cylinder had set the required time, the interior excavation was started and the sinking was produced by this excavation, with the occasional use of water jet and of weights on the top of the cylinder. This excavation was made with a specially designed orange-peel grab-bucket, made of ½-in. metal, with a 3-ft. 6-in. outside radius and weighing 1,560 lbs. In the first caissons vertical pipes were placed in the concrete to be used as jet pipes, but this device was not successful, so outside pipes around the cutting edge were used instead. Ordinarily, only a small amount of jetting was necessary, say three 3-hr. periods of 1½-in. pipes under 80 lbs. pressure for the total sinking of a caisson, when the sand level was reached.

At some of the cylinders the sand was so dense as to require additional weight. This was supplied by 40 tons of small pig-iron billets carried on a bracketed platform clamped to the top of the cylinder but leaving an opening through which all excavating operations could be carried on.

After the concrete had been laid in caissons, an average rate of sinking of about 6½ ft. a day was maintained through mud and about 1.5 ft. per day through dense sand. Counting in the time of concreting the cylinders, the average progress was 4 ft. a day through mud and 1.1 ft. a day through sand.

As described above, it was soon found that to carry the caissons to solid rock would be impossible within the time limit, and a belled bottom was designed to make the bearing surface a circle of 8 ft. diameter. This bell is shown in Fig. 7. It consists merely of a number of 3/16-in. flat plates tapered to care for the conical bell, each plate placed by a diver, so that it took about the same bevel as the inside of the cutting edge. In setting these plates the diver went to the bottom of the caisson, which was

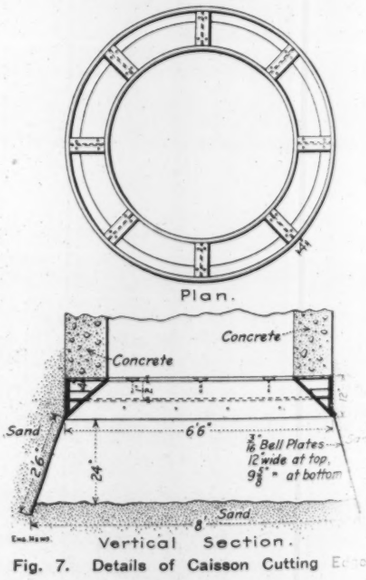


Fig. 7. Details of Caisson Cutting Edge.

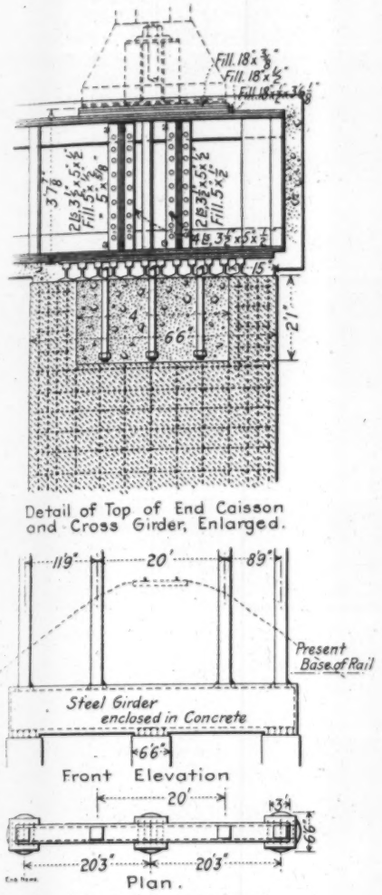


Fig. 9. Details of Bent 24.

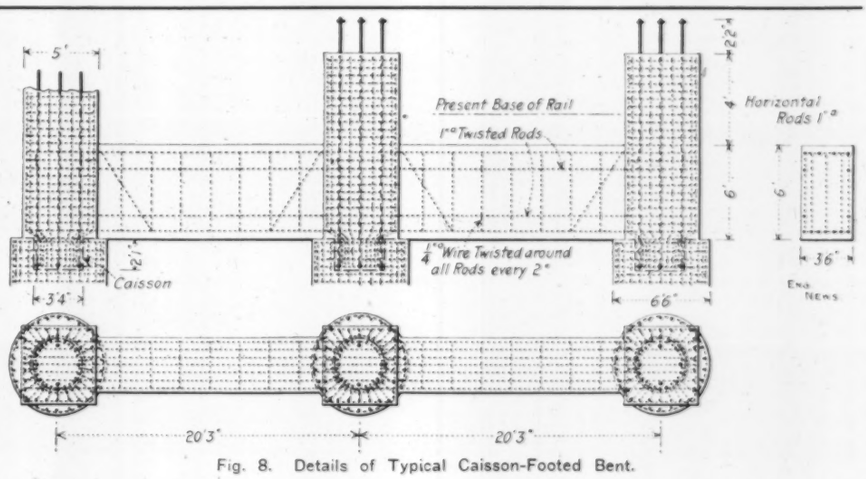


Fig. 8. Details of Typical Caisson-Footed Bent.

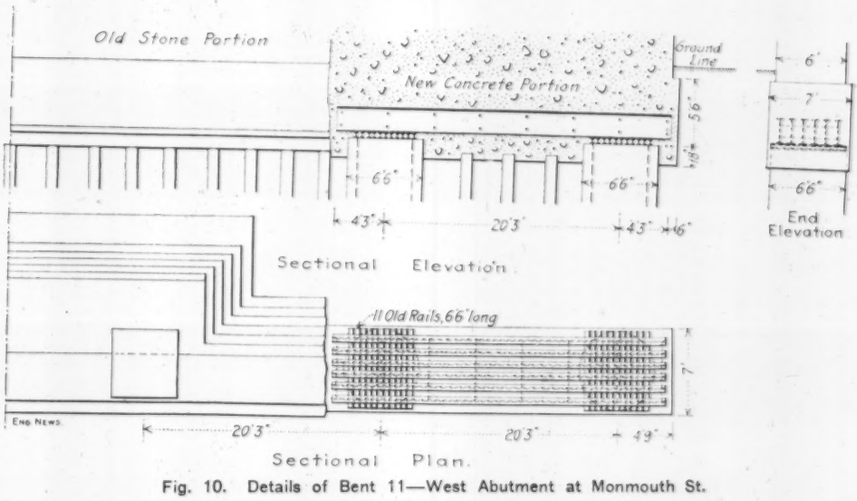


Fig. 10. Details of Bent 11—West Abutment at Monmouth St.

FIGS. 8-10. DETAILS OF DIFFERENT BENTS.

from 20 to 55 ft. below ground-water level, and by the aid of a water jet drove out the hard sand from around the cutting edge and placed the plates one by one, overlapping each other. At the bottom each plate was driven into the sand for an inch or two, and at the top it was sprung behind the cutting edge, as shown in Fig. 7.

In the first of the caissons in which the belling was tried, the cylinder was sunk to what the engineer considered a good, hard sand, fit to take the designed load. After the diver had placed the bell, at a depth of 69 ft., or 55 ft. below ground-water level, an attempt was made to pump the water in the cylinder out. At the first attempt, water was removed to within 5 ft. of the bottom when the pumps broke down and the hole refilled; on the second attempt the level was within 12 ft. of the bottom. After this very severe test on the solidity of the sand at the bottom of the cylinder, the engineer in charge went down, in a diver's suit, to the bottom and found that in no place had the plates been displaced or the sand run in under the edge. As a result it was decided that the stratum of sand in which this caisson had been stopped was amply strong to take the load. This stratum was then used to determine how far to sink the other cylinders; whenever it was reached, sinking was stopped and the bell placed. In every case, however, the hardest sinking, that is the slowest rate of progress, was in this stratum of sand.

It will be noted that the footings of Bent 18 are much deeper than any of the others. One of these cylinders was the first sunk and was carried much below the layer of sand noted above, in the hope of reaching rock. This idea was finally abandoned and the bell placed at the elevation shown (Fig. 4). On account of their proximity, the other two caissons in Bent 18 were carried to the level of the first, because it was feared that if allowed to remain at a higher elevation the loads might be transmitted across to the deep cylinder and add to its bearing.

In sinking the cylinders a number of boulders, such as were undoubtedly hit by the wash borings, were encountered and removed. In one case a stone 3½ × 3½ × 4 ft. in size was chained by a diver and lifted up through a cylinder. In another case small charges of dynamite were used to dislodge stones which got in the way of the cutting edge.

After the cylinders were excavated they were filled to the top with a 1:2½:5 concrete and the pedestals built upon them.

The south caisson of Bent 32 was put down to sand with a belled bottom, but the other two at this bent reached solid rock so that no belling was needed. In Bents 33-36 and in the west abutment the rock was so near the surface that the caissons were not needed and the square pedestals at the piers and the footings of the abutment were built directly upon the solid rock in open cut held back by sheathing.

In Bent 13, the south pedestal was placed on an old pile-footed pedestal which had been placed some years before with the view toward future construction. In Bent 11, cylinders were used for the north and middle column support, as described hereinafter.

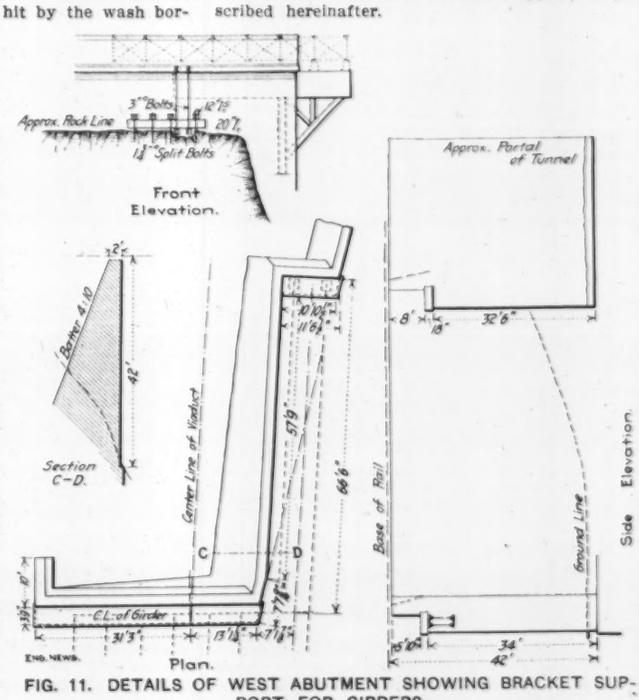


FIG. 11. DETAILS OF WEST ABUTMENT SHOWING BRACKET SUPPORT FOR GIRDERS.

Substructure.

PIERS AND ABUTMENTS.—There are two general designs of piers or pedestals under the bents, with a special design at each of the end abutments, at intermediate abutments, at street crossings, and at Bent 24, where there is a high level track crossing under the viaduct.

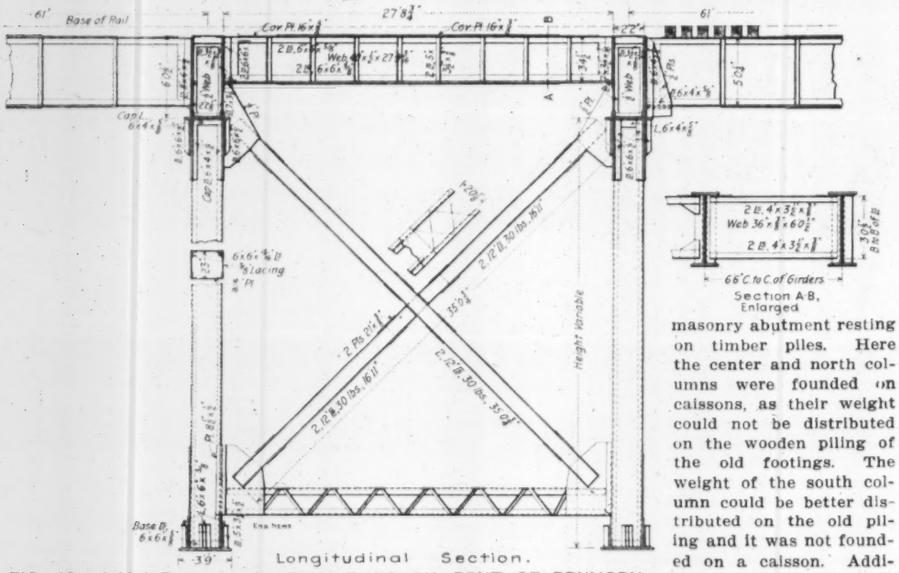


FIG. 12. LONGITUDINAL SECTION THROUGH BENT OF PENHORN CREEK VIADUCT.

From Bent 2 to Bent 9, where the footings are upon concrete piles, the piers supporting the columns are separate concrete pedestals, one for each column, generally pyramidal in shape and projecting about 18 ins. above the ground (Fig. 5). From Bent 12 to Bent 32, inclusive, the piers are after the general type shown in Fig. 8, varying only in the position of the pedestals to suit the various spacing of the columns. These piers consist of square section pedestals rising from the concrete-filled caissons described above and connected and braced by a heavy reinforced-concrete beam resting on the tops of the caissons. This connecting beam is below the present and final surface of the ground, so that all that appears of the pier above ground are the three pedestals. The pedestals and the caissons are joined together by continuous reinforcement from the one to the other.

A very thorough protection against electrolysis is provided at the top of each of the pedestals. First each of the anchor bolts and the nuts and washers holding them at the bottom were coated with Minwax, a patented preparation; then they were wound spirally with Minwax cloth, which was in turn painted with Minwax. The top of the pedestal was then coated with Minwax, the coating extending down the sides for 6 ins.; over this coating Minwax cloth was placed, which was in turn coated with Minwax. Then another layer of Minwax cloth was applied and covered with the Minwax fluid.

At Bent 24 there is to be an equipment track running under the viaduct on a high level, so that four columns were necessary to carry the main transverse beam. Rather than build four caissons to carry the pedestals under these columns, a different type of pier was designed (Fig. 9). Here the cross-girder was a steel plate-girder placed immediately upon the tops of the caissons and covered with concrete. The column pedestals were then built upon this girder as a support. Bents 33 to 36 rest upon separate pedestals reaching to the solid rock, which at this end of the viaduct is near the surface.

For the abutment on the east side and the pier on the west side of Coles St., the old masonry footed on wooden piles was used. For the abutment a special grillage of I-beams encased in concrete was provided as a seat for the girders, and on the other side of the street the concrete pedestals were placed directly on the old masonry. The pier for Bent 10 is the same as for Bent 1, but under Bent 11 on the opposite side of Monmouth St. a more complicated condition existed. At this pier there was an old masonry abutment resting on timber piles. Here the center and north columns were founded on caissons, as their weight could not be distributed on the wooden piling of the old footings. The weight of the south column could be better distributed on the old piling and it was not founded on a caisson. Additional wooden piles were driven, however, as an extra precaution.

The design is shown in Fig. 10. From this it will be seen that the north and middle caissons are topped by the usual I-beams encased in concrete, and the face wall of the abutment carried straight across these two into the old abutment, the whole being faced alike to present a uniform appearance. On top of this face wall the separate pedestals were placed, as in the other piers.

On account of the topography and the track conditions the design of the west abutment is out of the ordinary. As shown in Fig. 2, the girders under the three southerly tracks of the viaduct terminate at the end of one of the regular 61-ft. spans, but the girders under the north track continue for another 66-ft. span. This is because the alinement of the new tracks reaches the hill just at the side walls of the cut approach to the old tunnel. The old tracks, on which the traffic of the road is carried during the construction of the new viaduct, prohibited the extension of the north wall of the abutment at Bent 37 much more than 13 ft. beyond the center line of the viaduct, so the only solution was to build the abutment around the corner in the wall and to support the most northerly girders on a bracket projecting from the abutment.

This design is shown in Fig. 11. It consists of an ordinary stepped concrete retaining-wall abutment, founded on the solid rock, and filled in between with earth and rock fill. The three southerly tracks reach the abutment at what would be Bent 37 and the most northerly track at Bent 38. These latter girders at Bent 37 rest on a deep steel plate-girder which is supported on a bracket extending out of the concrete and held against the up-kick of the cantilever by an anchorage of I-beams, both encased in the concrete and tied into the solid rock under the abutment.

Superstructure.

The superstructure consists of 61-ft. plate-girder spans, between 31-ft. braced tower spans, with a 66-ft. span at each of the street crossings and for the north girders of the most westerly span. There are eight longitudinal girders, two for each of the four tracks, resting on cross box girders, in turn resting on three braced columns reaching to the separate concrete piers or pedestals. All connections are riveted, but at every fourth bent the longitudinal girders rest on the transverse girders in pockets forming expansion joints.

From Monmouth St. west the viaduct is crossed by a number of various kinds of tracks at different levels and this complicates the longitudinal interbracing of the columns and also the location of those columns. Thus, on Fig. 2, it will be noticed that at Bent 17 a crossing track requires that the middle and north columns be spaced 16 ft. 11 ins. and the middle and south columns, between which the tracks pass, 23 ft. 7 ins., and that the interbracing necessarily has to be placed between the former two columns. This same crossing track continuing diagonally requires that the columns at Bent 18 be spaced 27 ft. 9 ins., middle to north and 12 ft. 9 ins. middle to south, with the tracks in the former and the bracing in the latter, just the reverse of the conditions in Bent 17, which is part of the same tower as Bent 18. This same condition is repeated in the next tower on account of another track crossing. Similar crossings cause a change in column

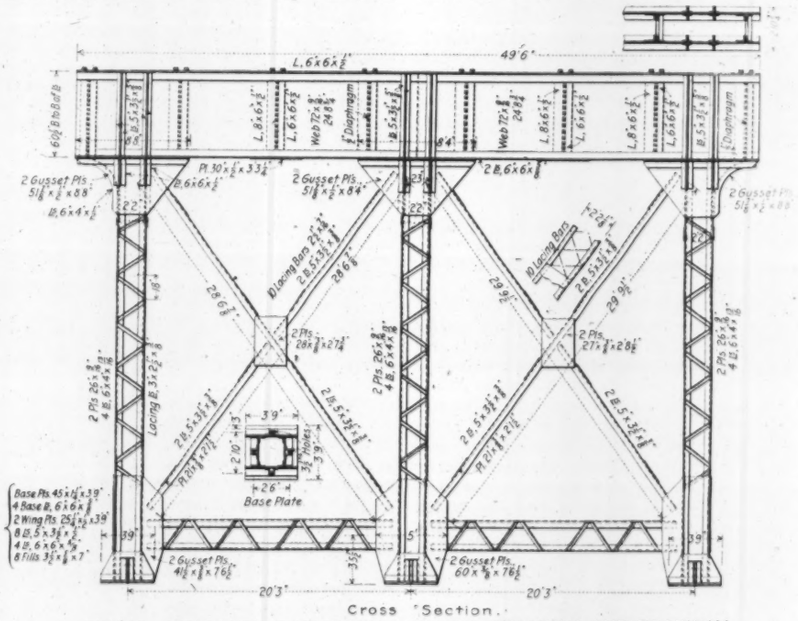


FIG. 13. TRANSVERSE SECTION SHOWING COLUMNS AND ROADWAY.

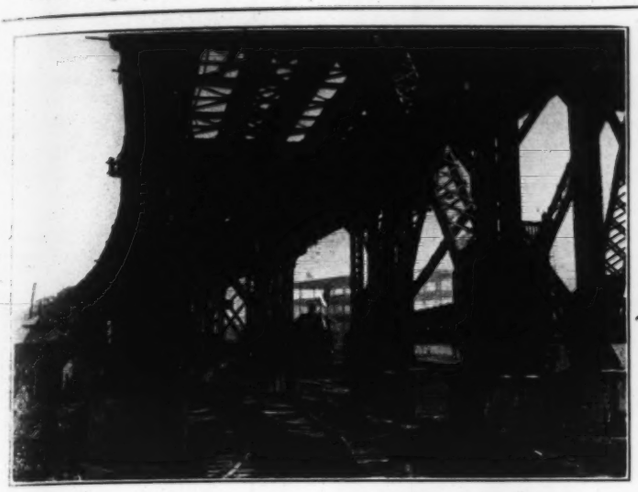


Fig. 14. Looking Through One of the Eccentric Bents.

Fig. 15. Looking West at Bent 32.

FIGS. 14-15. VIEWS OF PENHORN CREEK VIADUCT DURING CONSTRUCTION.

spacing at the different bents, which not only affects the cross-bracing but also the design of the transverse girder, because of the variation in the location of loads from the stringers and the reactions on the columns.

COLUMNS.—The columns are made up of four corner angles joined with plates in line of viaduct and with plates and lattice angles (Fig. 12-13) in the opposite direction. They foot on the concrete pedestals on a base plate and are connected thereto by 3-in. anchor bolts embedded in the concrete and fitting to the column in vertical grooves made of two angles riveted to each side of the column. In the direction of the transverse bearing-girders the caps of the columns are provided with plate brackets. Transverse bracing is between all columns where no railway crossing exists in the form shown in Fig. 13 two single angles spaced with the angle of the connected columns and laced together with plates and lattice bars. In the line of the bridge, bracing is provided between the outside columns of each tower and between the middle columns when there is no track crossing through the tower. When there is such a crossing the outside column bracing and the transverse bracing is judged sufficient to stiffen the tower. A typical longitudinal bracing is shown in Fig. 12. It consists of two channels spaced the same as the connected columns and laced with plates and lattice bars.

In the high towers toward the west end of the viaduct, those columns between which tracks pass are bracing together by transverse sway bracing above the clearance line of trains, but the other columns are braced as in the remainder of the viaduct. No horizontal bracing other than that afforded by the track girders is provided in any of the towers.

TRANSVERSE GIRDERS.—The details of the transverse girders spanning the columns and supporting the track girders are shown in the typical detail on Fig. 13. The spacing of the track girders is the same in all spans, but the column supports are at different spacings on different spans so that the moments, and consequently the section, of all the girders are not the same, but the general details are similar. Each girder is 49 ft. 6 ins. long and 6 ft. ½ in. deep and is made up of two webs, 2 ft. $2^{11}/_{16}$ ins. c. to c. with both inside and outside flange angles at the bottom and only inside flange angles at the top on each web. Directly over each column angle stiffeners are provided on each side of each web and at each track girder support the webs are stiffened by flat plates in the inside face. The two parts are tied together by plate diaphragms at each track girder support. The track girders rest on angle seats riveted to the webs of the transverse girders and are riveted to the webs also, except at every fourth bent, where the large 61-ft. girder rests in a pocket such as is shown at the right of Fig. 12 to form an expansion joint in the structure. The transverse girders are set upon the bracketed tops of the columns and are riveted thereto.

TRACK GIRDERS.—Each main track girder (Fig. 16) is a single web plate-girder 50 ft. 2⅛ ins. long and 5 ft ½-in. deep. There are eight to each span, two to each of the four tracks and they are tied together in couples at the upper flange by a continuous double post Warren truss system of bracing and at the lower flange by a similar system with a single post. The track girders across the towers are also single web plate girders, eight to the span. Each one is 27 ft. 8¾ ins. long and 3 ft. 4½ ins. deep. The cross-frame in both upper and lower frames are doubled-post Warren trusses continuous across the whole eight girders.

ROADWAY.—Throughout the viaduct the track is carried on ties laid directly across the longitudinal girders, but at street crossings drip pans are provided to protect passers by from passing trains.

ERECTION.—The erection was carried on entirely from the existing adjacent tracks by the use of locomotive cranes and derrick cars. The column bents were first erected and then the longitudinal girders, in pairs weighing as high as 33 tons, were swung into place by the cranes. At the western end of the viaduct where the bents were high stationary derricks and gin poles had to be used to swing the cross girders above the street railway bridge there.

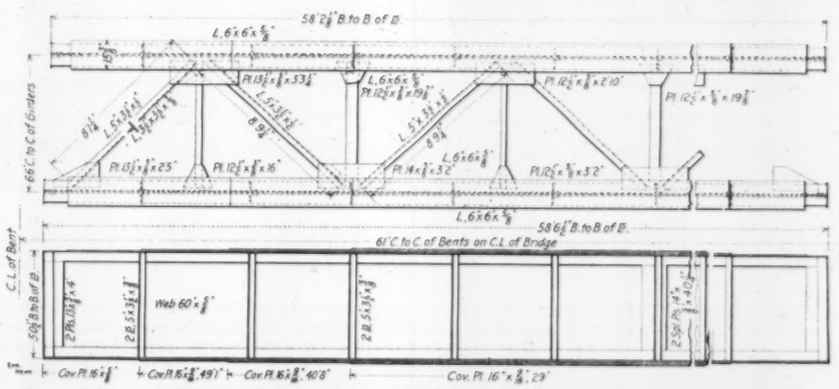


FIG. 16. DETAILS OF 61-FT. LONGITUDINAL GIRDERS AND CROSS-BRACING.

Engineering Organization.

The viaduct was designed under the direction of Mr. Francis Lee Stuart, M. Am. Soc. C. E., Chief Engineer of the Erie R. R., with Mr. F. A. Howard, Ass't Engineer Bridges and Buildings, in charge of the superstructure, and Mr. W. W. Drinker, Ass't Engineer, in charge of the substructure. The contractor for the superstructure was the McClintic-Marshall Construction Co. and for the substructure the Phoenix Construction Co., New York.

RAILWAY TIES AND SPIKE FASTENINGS are the subject of a progress report on tests of treated ties made by Prof. W. K. Hatt (Purdue University) and printed in Bulletin No. 124 of the American Railway Engineering and Maintenance of Way Association. The conclusions from this report may be summarized as follows:

No weakness was shown by treated ties as compared with untreated ties, either in rail bearing or spike holding strength.

The extremes of atmospheric temperature have an appreciable effect upon the strength of wood, especially when green. The warm timber was from 9 to 17% weaker than the very cold timber.

The strength of the common spike against withdrawal is increased when it can be driven to follow a bored hole. The shape of the point of the common spike, however, leads it to drive out of a bored hole, and the resistance to withdrawal is thereby lowered.

The lateral resistance of screw spikes depends on the diameter and length of shank under the head, elastic limit of the metal and character of the wood.

The smaller screw spikes give greater lateral and direct resistance per pound of weight than the large spikes.

The screw spike had from 1.7 to 3.8 times the strength of the common spike against direct pull, and from 1.2 to 2.4 times the strength of the common spike against lateral resistance. The variations arise from design of spike and material of the common spike. It would appear that the length of the thread of the screw spike might be reduced and the shank lengthened, thus reinforcing the screw spike and rendering it of more uniform strength. In other words, its excess longitudinal strength might be reduced to increase the lateral strength.

The direct pulling resistance and the lateral resistance of common spikes in untreated timbers are as tabulated below. The table gives also the average stress under the rail at the elastic limit of the wood:

	Resistance of spikes, lbs.		Stress in wood
	Direct pull.	Lateral.	at elas. limit.
Red oak	7,639	2,026	1,131
Lob. pine	3,930	1,633	578
S.-lf. pine	4,359	1,619	642
L.-lf. pine	3,955	1,650	690
Red gum	3,883	1,704	830

The Cracking and Partial Failure of Abutments and Retaining Walls.

By CHARLES K. MOHLER.*

The designing and building of masonry walls is one of the oldest and most monumental undertakings practiced in the constructor's art. Great and almost universal progress has been made in the art and science of engineering in recent years. It is with a degree of disappointment that we recognize the fact that very little real progress has been made in the field covering the design and construction of masonry bridge abutments and retaining walls.

It is almost the exception to see an abutment or retaining wall which has been constructed for some time that does not show signs of weakness, by tipping forward, developing cracks, or in some cases actually failing. Few of the tipping and cracked walls are the result of the section of the body of the wall having been made too light. In fact, many cracked walls are very heavy and have a great excess of section over what is required for stability, if properly designed. Many walls have an excess of masonry which is absolutely worthless as far as adding to stability is concerned, and so distributed as to be an actual detriment to the wall, in helping to bring about conditions producing cracks.

Out of about 300 wall sections available for examination and study, there is not a single one, in the author's judgment, that could not be redesigned with less sectional area and at the same time producing a wall with greater stability against tipping forward and developing cracks. The author has yet to see a plan for a bridge abutment where all of the elements which can well be employed to secure a perfectly stable wall, with the least required amount of material, have been embodied. Some improvement may be noted in this direction in recent plans over those of an earlier date.

Several reasons may be given to account for the poor showing that is usually made by constructed walls:

(1) Lack of Interest in Wall Design.—In general the designing of walls has not aroused the live interest on the part of engineers that the subject deserves. A wall failure such as we are considering, seldom if ever results in actual disaster or loss of life, as is likely to occur with the failure of a bridge span. In fact, a failure of a wall is hardly laid up against the designer or builder as anything to his discredit. If a wall tilts forward and cracks it is usually considered as a matter-of-course, can't-be-helped result.

(2) Limited Knowledge of Earth Pressure.—Our knowledge of the nature and amount of the earth pressure is limited almost wholly to small model tests. These are almost useless for practical information. The treatment of earth pressure from a theoretical basis is not accepted with any degree of confidence. Many important pieces of work are designed and constructed without any attempt being made to determine the amount and effect of the earth pressure on the wall. Walls are built with the ratio of base to height ranging all the way from 20 to over 100%. The great majority are between 40 and 60%. Tipping and cracking are not at all confined to the lighter sections.

(3) Middle-Third Theory Error.—The "middle-third theory" of the text-book is, in the opinion of the author, responsible for more bad wall designing than any other one thing. The theory is a safe working basis for the body of the wall itself, and the base or foundation when founded on hard solid rock. When the foundation is a compressible and yielding soil the case is altogether different. For a foundation which will allow even a slight settlement the rule should be for the resultant to pass through the base at or back of the middle. Some of the often repeated statements we hear are about as follows: "A stable and enduring structure cannot be built on a poor foundation." "Poor foundations are responsible for most of the wall failures." "The foundation is the most important part of a structure." The middle-third theory says "If you design your wall so that the resultant cuts the base inside the middle third the wall will be stable and safe." As just pointed out, for a yielding foundation nothing could be much further from the truth if the resultant cuts the base near the front of the middle-third.

The examples of walls given in the text books are equally bad, if not worse, than the instruction. Some years ago the author computed the foundation reactions for an abutment given in one of our text books. The section is almost typical of walls built a few years ago, and of many at the present time. It is only natural that it should have been largely copied. In estimating the foundation reactions, in this and other cases, the following assumptions are made. The estimates are for 1 ft. length of wall.

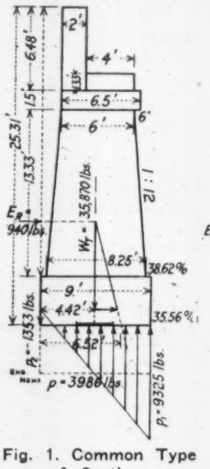


Fig. 1. Common Type of Section.

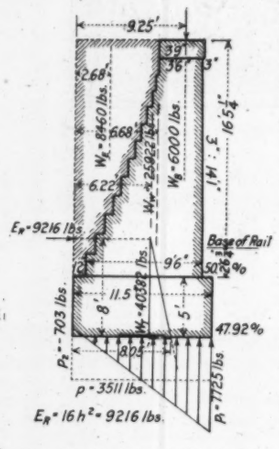


Fig. 2. Section of Abutment.

w = weight of one cubic foot of masonry = 150 lbs.

c = weight of one cubic foot of earth or backing = 100 lbs.

E = total horizontal earth pressure against the wall in lbs.

W_w = weight of wall in lbs.

W_e = weight of backing carried over vertical portion of wall in lbs.

W_b = bridge and live load per lineal foot of wall in lbs.

W_t = total foundation load in lbs.

p = average foundation load or reaction in lbs. per sq. ft.

p_1 = foundation reaction at toe in lbs. per sq. ft.

p_2 = foundation reaction at heel in lbs. per sq. ft.

Some of the features of the design, assumptions for loading and foundation reactions, are as follows:

The face and back batter of the wall are equal.

The footing offsets are the same front and back.

The ratios of base to height are: neat work, 38.62%; footing, 35.56%.

The bridge load W_b = 10,000 lbs.

The earth pressure E was computed from Rankin's formula, for 1½ to 1 slope, giving 14.3 h^2, h being the height in feet.

Under the above assumptions the resultant was shown to fall outside the middle third, giving the following reactions on the foundation (see Fig. 1). The toe load was 9,325 lbs. per sq. ft. The heel load showed negative 1,353 lbs. per sq. ft. The average foundation load per sq. ft. was 3,986 lbs. With an average foundation load of less than 4,000 lbs., we get a difference between the toe and heel reactions of 10,678 lbs. Under those conditions, can we expect the wall to do other than settle at the toe and tip forward?

(4) Defective Construction.—With a well-designed wall the material and workmanship may be so poor as to result in the failure or partial failure of the structure.

Examples of Failure.

As the author has made rather a sweeping charge of bad design and poor economy in the past and prevailing practice of wall construction, he can perhaps do no better than give actual examples of conditions to be found practically on every hand. Only a few can be selected almost at random from a collection of photographs.

Fig. 3 is a photograph of a wall, probably built in 1898. The photograph was taken in 1909. The wall has tipped forward and opened a crack at the junction with the wing or return wall, as well as at other points. On a piece of work having similar masonry abutments most of these walls are in the same condition.

Fig. 4 is a wing abutment built about 188[illegible]. It was photographed at the time it was being torn down, in 1909. The wall tipped forward and many cracks developed. Near the top it will be seen that many of the stones are actually sheared off at the junction of the wing with the body of the wall. The foundation soil is compact boulder clay.

Fig. 6 is a wall of the same wing as Fig. 3 and built probably at the same time. It was photographed in 1909. The wall was badly tipped and cracked. The original batter was 1 in 24. As will be seen by the plumb line on the left the wall has actually tilted forward until the overhang is almost as much as the original batter. In the tipping forward of the body of the wall it will be seen that the end of the wing has nearly held its original position, and the fourth step and the courses to the left and below have been carried forward, as clearly shown by the crack extending to the left and downward.

Fig. 5 is a wall built in 1905 and photographed in 1909. The retaining wall has tipped forward and cracked from the abutment.

Fig. 9 is a wall built about 1908 and photographed in 1910. The abutment has cracked or sheared off from the wing or retaining wall.

Fig. 7 is a retaining wall built in 1909 and photographed in 1910. Crack in wall some distance back from the abutment.

Fig. 8 is a photograph of an abutment in which a crack extends down near the middle. Built 1909. Photographed in 1909.

The walls shown are from constructions well distributed, and only one shown from any one piece of work. Anyone who has given close attention to the behavior of abutments and retaining walls in service will fully appreciate the illustrations given.

While the examples shown are not failures in the sense that any have actually tipped over, or that few of them ever would do so, still tipping and cracking to the extent shown can hardly be considered other than a failure in design. There is nearly every indication that the failure of the walls shown were principally the result of too great an excess of toe pressure on the foundation. The heavy wall sections give but little better results than the light. None of the walls shown were of any great height. With the foundation reactions properly distributed and the wall well constructed it should not tip and crack. The failures of some of the walls shown can be well accounted for by an analysis of the actual sections.

Fig. 2 is based on the original drawing for a wall of which a number were built in 1897 and all tipped forward. The neat work ratio of base to height is 50%. Ratio of base of footing (for assumed depth) to height = 47.92%. In estimating the foundation reactions the same assumptions were used as in Fig. 1 except that the bridge load was taken at 6,000 lbs. per lin. ft. of wall. The resultant falls outside the middle third. The average load per sq. ft. of foundation is 3,511 lbs. The toe pressure is 7,725 lbs. The heel, minus 703 lbs. It might be remarked in passing that the original drawing for this wall bears the signature of approval of two leading engineers.

Revised Sections of Walls.

A number of "revision" sketches were made up in connection with this study with some of the following results:

In Fig. 1 the same ratios of base to height were used, as in the original. Some entirely useless section was eliminated at one point and some added to another, which was fundamentally weak.

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The total area was increased from 156.03 to 157.07 sq. ft., or 0.6% increase. The average foundation load $p = 3{,}911$ lbs. Toe reaction, 3,911 lbs. Heel the same. Resultant cut base in the middle.

In another case under the same conditions as above only the useless portion was eliminated without adding to the weak portion as above, and the outline of the section changed. The area of section was reduced from 156.03 to 151.84 sq. ft. a decrease of 2.6%. Average foundation reaction obtained $p = 3{,}876$; Toe load $p_1 = 4{,}031$, and heel load $p_2 = 3{,}711$ lbs.

In a "revision" sketch for Fig. 2 using the same ratios of base to height as in the original, eliminating 8% of useless area, and using 39.3% of water earth pressure, the resultant was made to pass through the middle of the base. Average foundation load $p = 2{,}981$; Toe load $p_1 = 2{,}981$, and heel $p_2 = 2{,}981$ lbs.

As a case of "the proof of the pudding," etc., the author can refer to a wall built in 1901 which he designed. The main features are as follows: Total height, 29.5 ft., Depth of footing, 6 ft. Ratios of base to height, neat work, 42.04%; footing, 53.83%. Earth pressure, Rankin's formula. Average foundation reaction per square foot, $p = 3{,}581$ lbs. Toe reaction, $p_1 = 3{,}724$ lbs. Heel reaction $p_2 = 3{,}438$ lbs. Resultant cut base 0.14 ft. in front of center of base. Foundation wet, and soil practically amounting to fine quicksand. The wall was joined onto and made a continuous part of an old abutment wall to provide a third track along the existing double track. It is reported that the wall has not tilted forward or developed any cracks up to the present.

Fill in Front of Wall.

In figuring the foundation reactions of revisions no account was taken of the existence of the counter pressure produced by the depth of earth in front of the wall. That however is a factor of considerable importance when we consider that at the high position of the wall the ratio of depth of fill in front of the wall to that at the back is small, and the earth pressure and foundation loading are the greatest. At the ends of the wings the ratio between the fill in front and that back of the wall is large while the earth pressure and foundation loading are least. Those conditions of course constitute another factor that is instrumental in producing cracks in the wings of walls. The above is the cause that was largely instrumental in keeping the end of the wing in position and causing the crack, shown in Fig. 6, where the higher position of the wall has tipped forward and pulled away from the end or low position of the wing. It unquestionably forms a factor that should be taken into account and provided for in designing. For some time past the author has attempted to take care of the difficulty in a measure by the use of the following empirical formula to determine the width of base of footing on ordinary foundations. The following is the formula:

$b = rh + .12\ (h' - h'')$, in which

b = the width of the footing or foundation base.
r = ratio of base or thickness to height used for neat work.
h = total height of wall, from base of footing to top of wall.
h' = height of neat work.
h'' = height or depth of footing (or depth of fill in front of wall).

Defective Construction.

While poor design is the cause of most cracked walls, bad construction is responsible for some failures and cracks that otherwise would not have occurred. There is one fault in stone construction, and another in concrete, to which the author would like to call attention.

In stone construction, unless particular attention is given to see that all joints are thoroughly filled with mortar, even with the best quality of stone, a weak wall may result. In the cutting of stone the under bed is usually left relatively quite hollow. To get a perfect bearing over the entire bed joint will require, a rounded bed of rather soft mortar. A very common practice of builders is to use stiff mortar, ridged up all around the edge. As a result the stone has a slight bearing at only a few points. In making up the vertical joints it is often done by throwing in loose spalls and then daubing some thick mortar over the top. See Fig. 4.

In concrete construction the author believes it is a very serious error to fill the forms for a wall from 10 to 30 ft. high, in from half a day to a day. That is particularly the case where very wet concrete is used. When the work is started the framework of the forms seldom if ever has a snug bearing against the fastenings. Neither are the frames or sheeting of the forms stressed. As the filling proceeds pressure is developed and the

Figs. 3 and 4. Abutments Tilted and Cracked by Settlement at Toe. Fig. 5. Wall (in rear) Tilted.

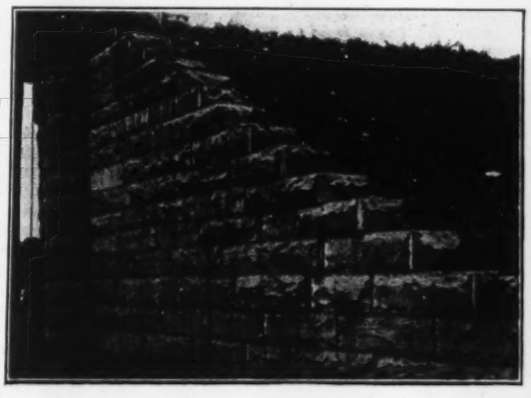
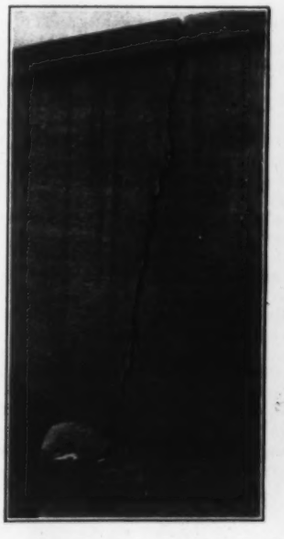


Fig. 6. Abutment and Wing Wall Tilted.
(The end of wing wall retains its original position.)

Fig. 9. Sheared Abutment.



Figs. 7 and 8. Cracks in Retaining Wall and Abutment.

Fig. 10. Repairing an Abutment.

EXAMPLES OF FAILURES OF ABUTMENTS AND WALLS.

forms forced out to a snug bearing and the frame work and sheeting stressed. That will leave the first layers which has partially set without lateral support. As it has not had time to develop strength to carry the load it will be crushed and forced outward leaving a weak and poorly coherent mass. Fig. 10 is a photograph of a crack extending through a concrete abutment. The face of the wall has been dug out and some pieces of rail fitted in with the idea of giving a bond, when the face was concreted up again. The crack was not sharp and clean cut but loose and discolored stone extended back for some distance in the interior of the mass each side of the open crack. It had the appearance of having developed a line of weakness before the concrete had fully set. In less than a year a new crack opened up near the end of the abutment. The patch over the old break shows no sign of a crack. If the thin patch of new concrete not over 18 ins. thick, with three short pieces of rail will hold the old break, and a new crack open up a short distance away, the indications are that the wall is very weak. The retaining wall extends back from the face of the abutment at right angles and is tipped outward. It is hard to account for the excessive cracking of some walls in any other way than that indicated.

When we take into account the fact that for short span bridges the cost of the substructure, usually far exceeds that of the superstructure, the question of economy in design is one of considerable importance. When we add to that the poor results for stability previously shown, it would seem the subject is one which needs a thorough study to bring out the practicable possibilities in designing abutments and retaining walls to secure stable structures at the least necessary cost.

First-Hand Impressions of German Sewage Disposal.

By H. N. OGDEN,* M. Am. Soc. C. E.

Although for the three weeks prior to the writing of these notes the author gave his whole time to the inspection and study of sewage disposal plants in southwestern Germany, he cannot hope that the impressions which he has formed upon the subject will have any great or lasting value. However, the general attitude of the German authorities upon this question seems to be so well established, and has, besides, such a reasonable basis, as to make it of considerable interest to engineers in America, where conditions of stream pollution are quite similar to those in Germany.

Unlike the rivers of England, which are often smaller in volume than the quantity of sewage discharged into them at any one point, the rivers in Germany are in many cases comparable with those in the United States. The city of Frankfort-on-Main, for example, with its population of 375,000, discharges into the river Main, where the sewage flow is diluted 125 times. Similar conditions prevail at Hamburg, where the River Elbe has been artificially made over into a superb inland harbor. Similarly, the sewage of Leipzig is discharged into the River Elster, the sewage of Halle into the Saale, the sewage of Wiesbaden and of Cologne, into the Rhine.

Broadly speaking, the German attitude toward stream pollution is one of no discrimination between domestic sewage and manufacturing wastes, a careful guarding against putting unnecessary obstacles in the way of manufacturing industries, and a purification of domestic sewage only to that point necessary to prevent a nuisance after its discharge into a stream.

All this is in marked contrast to the attitude of some of the boards of health in the United States, which insist upon carrying the purification of domestic sewage to a point where it becomes practically drinking water, and at the same time offer practically no objection to the discharge of an unlimited amount of trade wastes into the same stream at the same point. The decision of the English court in the matter of the necessary purification of the sewage of Birmingham, laying it down as a principle that the sewage was purified in the eyes of the law if it had been so treated as to cause it to become equal in purity to the water into which it was led, may be cited as significant in this same connection.

As a logical deduction from this attitude of the authorities, the writer has observed that the preliminary processes of treatment alone have been commonly used in the German cities, and that the more refined methods used in England, where without doubt such methods are necessary, have not been practiced. These preliminary methods have been either screening alone, sedimentation alone or sedimentation with the addition of chemical reagents. In the first class may be cited Hamburg, Cologne and Wiesbaden; in the second class, Hannover, Cassel, Marburg and Frankfort; and in the third class, Leipzig and Halle.

HAMBURG.—The sewage of Hamburg is brought to the screening chamber from two sewers, one 9.56 ft. and the other 16.1 ft. in diameter, the flow joining to pass through a coarse screen made of wrought-iron pipe of 1¼-in. diameter with a clear opening of about 4 ins. This preliminary coarse screen is generally used in all plants in order to protect the works from heavy pieces of wood and other floating matter which might acquire force enough with the current to injure the more delicate machinery.

The screen proper is a revolving belt screen about 30 ft. wide, suspended at a small angle with the vertical. It is built up of steel bars ⅝-in. thick and spaced ⅝-in. in the clear, the bars being 12 ins. long between the rods on which the revolving screen is built up. This arrangement of rods and bars allows the belt to pass over drums at the top and bottom, which are driven by a chain drive from an electric motor. The method of cleaning the screen is by means of a horizontal comb engaging the belt screen at the back about 6 ft. below its highest point. This comb is arranged automatically to engage and disengage, and to come under a brush which cleans it, and pushes the debris onto a movable belt. The belt delivers the material into small cars. After a short run the contents of the cars are dumped onto a worm conveyor which carries the material up and out through a chute into a specially-designed barge. The delivery by barge is by contract, for which the city pays at the rate of about 3 cts. per cu. yd.

The sewage passes from the screen directly into the river without further treatment, and discharges through two pipes so located that the openings are at considerable distances apart. The manager stated that there has never been any nuisance created, and that only upon one or two occasions have fish been known to be killed from the effects of the sewage, and that these instances were traced to the presence of an unusual amount of sulphuric acid in the sewage. He also stated that very seldom and only in the winter could anything in the nature of a grease film upon the river surface near the outlet be detected.

COLOGNE.—At Cologne the purification of the sewage consists again of screen treatment alone. There are two sets of screens, each set containing four units, the first set having a clear opening of about 10 mm. (⅜-in.) and the second set a clearance of about 2½ (1/10-in.) mm. The screen part proper is stationary, being composed of a framework of steel bars of rectangular cross-section, suspended in the water at a small angle with the vertical. The cleaning apparatus consists of steel wire brushes of a length equal to the width of the screen, mounted at the two ends upon a link chain which runs in grooves parallel to the face of the screen. These grooves were placed at such a distance from the face of the screen as to cause the brushes to exert sufficient pressure upon the steel bars to carry along the retained matter. These horizontal brushes are mounted upon the chain at intervals of about 4 ft. They are themselves cleaned in turn by passing across a steel comb at the extreme upper limit of their motion. The rakings drop from this comb upon a belt transporter, which carries them off to the side and dumps them into small cars. These cars are then pushed by hand out of the building and to a nearby set of sludge bins.

The total average flow per day thr[ough] the screens is about 15,000,000 gals., and th[e rakings] per day amount to about 27 cu. yds. [The efflu]ent is passed directly into the river, wh[ere it] undergoes a dilution of about 1 to 3,000.

The screen mechanism here, when c[ompar]ed with that at Wiesbaden or at Frankfo[rt] seems much simpler and apparently offers no ob[jection] to a regular and efficient cleaning. It seem[s] also, to have an advantage over the revolvi[ng] belt screen found at Hamburg, although it wa[s] pointed out that a laborer was always at hand to remove pieces of cloth and fiber, which the steel brushes would not be able to cope with.

WIESBADEN.—The treatment at Wiesbaden involves the use of three kinds of screens: a coarse screen of about 4-in. clearance, a finer screen of about ⅜-in. clearance, and a horizontal brass plate screen with holes 2 (1/12-in.) mm. in diameter. The ⅜-in. screen was of particular interest and efficiency, and was exactly that of the screens in use at Frankfort, except that at the latter place three machines were installed side by side, with five radial arms each, whereas at Wiesbaden one machine was sufficient, the number of arms, however, being increased to six.

Each rotary screen consists of a horizontal shaft from which a number of screens radiate, the space between the bars of each screen being only 10 mm. (⅜-in.). The shaft, which is fixed a little above the level of the sewage, rotates slowly, thus causing each radial screen to descend into the sewage and gradually to emerge again from the same, when the arrested matter is removed by an India rubber scraper and pushed onto a transporter, which delivers it into small trucks in a separate chamber. The matter intercepted in the catchpit is dealt with in a similar manner, and the trucks when full are lifted into carts on the surface, the refuse being ultimately disposed of on land. The whole plant works automatically, being driven by machinery, and hand labor is as far as possible avoided.

According to the figures given by the engineer at Frankfort, the catchpit preceding the ⅜-in. screen removes from the raw sewage, which contains on an average about 800 parts of suspended matter per million, 16%, while the ⅜-in. screen removes 10%, so that the combined effect of the catchpit and screen is to remove from the sewage about 26% of the suspended solids. The success of screens of this sort seems assured, but the experience gained at Wiesbaden has shown that the use of the finer screen is not so satisfactory. The manager at Wiesbaden expressed himself to the effect that the value of the fine screen was not in any way comparable to that of a moderate-sized sedimentation basin. He pointed out that the appearance of the sewage after passing through one of the fine screens was rendered worse rather than better, and that this was due undoubtedly to the action of the fiber brushes in rubbing particles of suspended matter, through the screens converting them into a more nearly colloidal state. He also remarked in this connection that experiments had shown that it took longer for a given proportion of the suspended particles to settle out of the sewage after treatment with such fine screens than before. After his experience of eight years with the fine plate screens he has concluded that better results would be obtained by substituting sedimentation tanks for the screens, and plans are now being drawn up with this in view.

HANNOVER.—The sewage of Hannover, which consists of about 6,000,000 gals. per day, is passed through twelve sedimentation tanks, each 131 ft. long, 21.3 ft. wide and 8.2 ft. deep, four of the tanks, however, being always withdrawn from use for purposes of cleaning. This tank capacity amounts to about 1,400,000 gals. always in use, or nearly one-fourth of the daily flow of the sewage. The effect of these tanks is to remove from the sewage 133 cu. yds. of sludge per day, the sludge containing from 92 to 93% of moisture.

The most interesting feature, however, of the Hannover plant, was the use of the Schaefer-ter-Meer centrifugal machines for drying this sludge. From 70 to 140 cu. ft. of the raw material can be treated per hour with one of these machines.

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...ed the ejected dry material obtained from this ...quantity of sludge weighs from 660 to 1,000 lbs. ...From 1 cu. ft. of raw sludge, containing 90% of ...ater, 8 to 12.5 lbs. of dry material is separated, ...ist about 40% to 66% of all solid matter con...ned in the sludge is removed. The residue is ...back to the settling tanks, where it again ...posits the sludge held in suspension in it. In ...nsequence of this either the quantity of raw ...udge treated each day is somewhat increased ...the sludge deposited in the settling tanks is ...ore highly concentrated than before the resi...ue is led back to the latter. The actual clarify...g effect of the plant is not, however, influenced ...y this circumstance.

On leaving the machine the dried matter has the appearance of vegetable mold, and is of such consistency that it can be handled with a spade and can consequently be conveyed from one place to another like soil or gravel. It contains about 60 to 70% of water. Its volume as compared with that of the raw sludge is, therefore, reduced to about 20 to 14% of its original bulk.

It is interesting to know that New York City has recently purchased one of these machines to be used in connection with its chemical precipitation plant on Coney Island. At the time of the visit of the writer to the factory where these machines are made, he was informed that one of their experts would soon be on his way to the United States to superintend the setting up of this machine and to give any advice or assistance in his power to other municipalities which might be interested in the use of such a method of treating sludge. These same machines are also in use at Frankfort, and the manager there is apparently convinced of their superiority to sludge presses, not because of their greater efficiency in drying the sludge as compared with presses, but because of the greater economy resulting from the elimination of manual labor.

CASSEL.—The population of Cassel is 150,000, so that the sewage flow is presumably from 5,000,000 to 6,000,000 gals. per day. The size of the tanks, which are five in number, is 131 x 13.1 x 9.9 ft., making a total capacity of about 650,000 gals., or 10 to 12% of the day's dry weather flow. The amount of sludge taken out by these five sedimentation tanks was about 92 cu. yds. per day, containing about 90% of water. This sludge is pumped onto fields, where it is allowed to dry, after which it is mixed with street sweepings and ashes, and afterwards carted away to be used for fertilizer.

MARBURG.—The population of Marburg is about 23,000, and presumably the day's flow is, therefore, about 1,000,000 gals. There are two sedimentation tanks, their combined capacity being about 100,000 gals., or about 10% of the daily flow. The amount of the sludge taken out by these sedimentation tanks daily is about 8 cu. yds. This, after being mixed with a certain amount of garbage and ashes, and partially dried, is sold to farmers at the rate of about 9 cts. per cu. yd.

FRANKFORT.—The sedimentation tanks at Frankfort are probably more scientifically designed than any others in Germany, and the results justify the large amount of experimentation that has been going on at that city for a number of years.

The amount of sewage is about 12,400,000 gals. per day, and for the purpose of purification there are 14 tanks, 134 ft. long, 19 ft. wide and 8 ft. deep, thus giving a combined capacity of about 2,100,000 gals. or about 17% of the daily flow.

As an index of the character of experimentation carried on at Frankfort, the accompanying table is given from a report by Messrs. Uhlfelder and Tillmans, who were connected with these experiments.

TABLE SHOWING THE EFFECT ON PURIFICATION OF VARYING THE NUMBER OF TANKS AT FRANKFORT.

No. of tanks.	No. of observations.	Average velocity of flow through the tanks. Mm. per sec.	Ft. per sec.	Reduction of suspended solids effected, in per cent. Total solids.	Organic solids.
2	7	28.3	.093	51	46
4	14	14.9	.049	68	64
6	14	9.8	.032	72	69
8	13	7.5	.025	75	73
10	13	6.0	.020	75	72
12	14	5.1	.017	77	71

Their comment on the showing of the table is as follows:

It will be seen from this table that with a velocity of flow of about 10 mm. per sec., which means a treatment of the sewage in at least six tanks, 75% of the suspended matter in the raw sewage is taken out. It is, moreover, further seen that there is not much difference in the effects produced by treatment in 6, 8, 10 and 12 tanks. The same degree of purification is also attained with 10 mm. velocity of flow as with 5 mm. Judged by these figures our plant would be considered too large, but we do not regard the size of our plant as unjustifiable, as its very size makes its operation a more simple matter. At any rate, it is certain that an enlargement of the plant will be unnecessary for a long period.

The report contains much that is of great interest and the above quotation is given to indicate the nature of the experimental work carried on and recorded in this report.

LEIPZIG.—At Leipzig, the sewage passes through a coarse screen of 3 ins. clearance and thence into a pump well, where a chemical reagent is added. This is a solution of sulphate of iron, the amount of the solution being proportional to the flow of the sewage at the rate of 4 grs. per gal.

The sewage, with its dose of chemical, is then passed through pumps, ensuring a good mixture, and is discharged into the eight settling tanks. Each of these tanks is 44 ft. × 262 ft. × 5.4 ft. deep. The capacity of the eight tanks is, therefore, about 450,000 gals., or about 18% of the daily flow, which is said to be 26,000,000 gals.

The effluent from these tanks, although of a yellowish tinge, contained apparently but little suspended matter, and was noticeably less turbid than the river into which it was discharged. No figures were available to show the exact purification effected or the amount of sludge taken out. The small capacity of the tanks is of interest when compared with the earlier English practice, although there is but little difference between the size of the tanks here and those at Frankfort or Cassel.

HALLE.—The sewage at Halle is treated with milk of lime and a chemical preparation made by the firm of F. A. Rob. Muller, of Schoenebeck, said to contain a sulphuric "Thonerde" and silica hydrate. The amount that the buckets which discharge the chemical take up each time can be regulated according to the requirement of the sewage entering from day to day, and in order to determine the needed amount tests are continually being made.

From the chemical mixing chamber the sewage is led through a screen to take out such solids as straw and wood, and on into a circular sedimentation tank, the lower part of which has the form of an inverted truncated cone, the upper part being cylindrical in form. A vertical pipe extends through the middle to the bottom of this tank, leading to a sludge pump, by which the sludge is pumped to a press.

The sewage flows into this circular tank through an outside channel, flowing down through this channel and entering the tank just at the bottom of the cylindrical part. The overflow is over a set of five weirs at the top, into a circular channel and from this channel through a straight channel into a tank exactly like the first, where the sewage has another opportunity of depositing the coagulating solids. From this tank the sewage is allowed to run either through an underground discharge pipe out into the stream at a depth below the lowest water level, or may be diverted into an open gutter, also emptying into the stream.

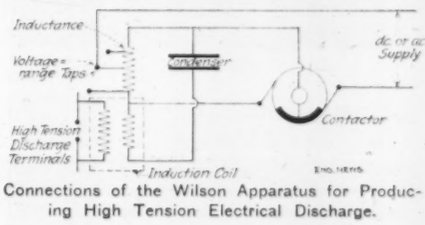
The amount of water treated per day is about 650,000 gals., while the capacity of the tanks is 36,400 gals., or only 6%. The amount of chemical added is 6 grs. per gal. of lime and one grain per gallon of "Thonerde." About three tons of sludge are taken from the tanks each day.

In conclusion, it may be said that while other methods, more complete and efficient, were studied, those described show what has seemed to the writer to be the features characteristic of German methods. Their peculiarity, in a word, lies in the fact that the purification is carried only the smallest possible length, instead of the greatest possible, as has been insisted on by so many sanitarians. Viewed from this standpoint, cities on such rivers as the Hudson, Susquehanna, Delaware and Alleghany would not be forced by state authority to construct contact beds or sprinkling filters but would, by screening or sedimentation tanks, satisfy all their demands. Nor does it seem to be material to the Germans that the river has been already polluted in times past so that a purification of the river water might be effected. They recognize, apparently, the fact that a river, flowing through and by a number of manufacturing cities, carrying shipping of all kinds on its surface and receiving waste waters from many factories, is not and cannot be drinking water and that to establish a high standard of purity for sewage effluents is to impose a needless and burdensome tax on those cities. This is surely reasonable and sane and a proper basis for sanitary legislation in the United States, where questions relating to the necessary extent of sewage purification are now pressing for a wise solution.

A New Method of Producing High-Tension Electrical Discharges.

In a paper before the British Association for the Advancement of Science at Sheffield, England, the first week of September, Prof. Ernest Wilson, M. Inst. E. E., and Mr. W. H. Wilson, Assoc. M. Inst. E. E., described a novel scheme for producing high tension electrical discharges. It was claimed that great improvement in reliability, portability, first cost and efficiency of apparatus had been secured.

The principle of operation may be seen from the accompanying figure. The terminals of an inductance, or choke coil, are connected to a source of electric current long enough to have a maximum amount of energy stored as magnetism; current is then broken and the released



Connections of the Wilson Apparatus for Producing High Tension Electrical Discharge.

energy is allowed to surge into a condenser through the primary winding of a transformer or induction coil; finally the inductance itself is short circuited. These operations are carried out by a contact maker which is driven by a small motor arranged for either direct or alternating current.

When the supply circuit is connected to the terminals of the inductance a small "inverse" e. m. f. is induced in the secondary winding of the induction coil, or transformer, but it is negligible or it can be eliminated by a modification of the connections. At the break of the supply connections, the energy in the condenser is added to that stored in the inductance as magnetic energy and which surges into the condenser at the moment when the condenser has received the whole energy stored in the inductance (due to the proper selected capacity of the condenser and to its having a relative counter charge before breaking the supply connection) the contactor short-circuits the inductance and the condenser rapidly discharges through the primary winding of the inductance coil. This circuit is purposely arranged having a natural high oscillation so that the condenser discharge oscillates through it in a well defined way giving use to the high potentials in the secondary.

PENSION FOR RAILWAY EMPLOYEES.—All employees on the New South Wales Government railways and street railways are required to contribute 1½% of their wages to the pension fund. The Government contributes $75,000 per annum. Pensions will begin at the age of 60 to each employee who has completed at least ten years of service and will be 1/60th of the average salary of each year served. In the event of death or voluntary retirement before the age of 60 the contributions are refunded.

A New Filter-Sand Washing Machine.

There has recently been installed at the slow sand filters at Choisy-le-Roi, France, a sand washing machine of new design invented by M. Boistel. According to a recent article in "Le Genie Civil," this machine has proved remarkably successful. From that article we abstract the following account.

Fundamentally, the washing machine consists of a sand pump traveling on a girder which spans

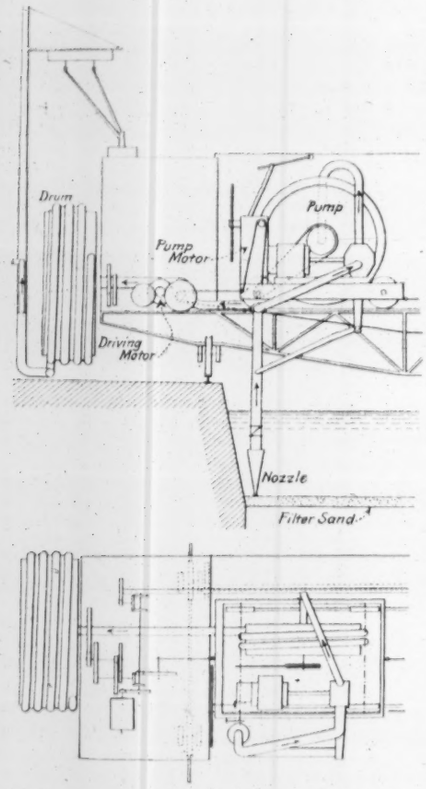


Fig. 1. Elevation and Plan of the Boistel Filter-Sand Washer in Use at Choisy-le-Roi, France.

the short length of the filter bed, and which travels in turn along the long length of that bed, after the same fashion that a traveling crane in a shop is manipulated. This traveling girder runs on rails on the side of the bed and can be switched from one bed to the other with ease.

Fig. 1 represents an elevation and plan of the pump and the end of the traveling girder. As

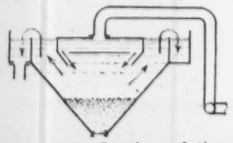


Fig. 2. Diagrammatic Section of the Sand Separator Used in Connection With the Boistel Sand Washer.

will be noticed from the elevation, the pump is of the ordinary centrifugal design, mounted on a trussed girder and carrying from its suction end a pipe which goes down under the water to the top of the sand in the filter bed. This pipe is provided at its lower end with a suction nozzle, the penetration of which into the sand can be controlled from the bridge above. In operation the pump, driven by electric current taken from a nearby trolley, as shown, sucks up the sand to the desired depth and pumps it through a rubber tube which is carried on a drum shown on the left side of the bridge to the separator, stationed at a convenient place in the midst of the six beds. This drum cares for the extra length of rubber pipe, so that it will not kink or get in the way while the bridge is being rolled down the length of the beds. The nozzle of the suction pipe is first put into the sand and the pump moved under the same electric power across the girder to the opposite side of the bed. The whole girder is then moved under power along the bed so that in the crossing back the nozzle will take up the sand just next to the line taken up in the previous trip. According to the report, the six beds, comprising some 19,400 sq. ft., can be surface cleaned in three hours, the machine being operated by one man.

Fig. 2 shows in diagram a section through the separator. The dirty sand enters through the pipe above under a considerable velocity, and striking the plate below the entrance is slowed down so that the heavier sand drops to the bottom of the cone while the mud and dirt is carried with the water up above the side plates into the channels shown. When sand has to be replaced upon the filter bed it is removed through the bottom of the cone, as shown.

Drainage of Irrigated Lands with Special Reference to Experiments in Utah.*

By CHARLES F. BROWN,† Assoc. M. Am. Soc. C. E.

The general need for drainage of irrigated lands has increased rapidly during the last twenty years. The most productive lands of these regions and those which were first brought under cultivation are, in many instances, now abandoned or fit only for wet pasturage. In Utah alone there are approximately 200,000 acres of irrigated lands needing drainage. Salt Lake Valley has about 34,000 acres of such lands, and several other valleys from 10,000 to 30,000 acres each. There are several localities in which, of the total irrigated lands, 50% are in such condition. California, Colorado, Washington, Montana, and Wyoming are likewise affected more or less, and in time all of the newly irrigated lands will have their problems of drainage. It naturally devolves upon the holders of such lands to reclaim them. To the end of developing the best methods for accomplishing the reclamation of such lands the Office of Experiment Stations has conducted drainage investigations in Utah, California, Oregon, Washington, Wyoming, Colorado, and Nebraska, with results which justify the conclusion that there is scarcely any land in the irrigated region which formerly produced paying crops, and later became affected by excess of water or alkali, that cannot be profitably reclaimed, provided the work is correctly planned and carried out. These results also point to the possibility of reclaiming many virgin lands containing an excess of alkaline salts.

This bulletin, while it applies to all irrigated lands and contains some data obtained in investigations in other states, is based upon experimental work done in Utah. The drainage investigations of the office were begun in the state during the summer of 1904 in cooperation with the Utah Agricultural Experiment Station. Since then the work has been carried on with a fund provided jointly by the State legislature and the Office of Experiment Stations, the Utah station acting for the state.‡

The individual landowners have in every case cooperated with the state and federal agents in carrying out the work. The attitude of most of them has naturally been one of skepticism as to the success which could be obtained, and they have been convinced of the feasibility and financial advantage of the methods proposed only by actual successful demonstrations of results on a commercial scale. In one case the county interested also cooperated in the expense.

Hyde Park Experiment.

This experiment was made on lands just south of Hyde Park, in a belt of 2,000 acres, between that town and Logan, which was badly affected by the rise of ground water. The soil is a black loam underlain by yellow clay, both of which are of an open nature and permit the passage of water freely. These lands were among the first brought under cultivation in this neighborhood and originally produced abundant crops. But after some twenty years of satisfactory cultivation, a rise of ground water resulted from the irrigation of the higher lands which had in the meantime been brought under cultivation. The amount of seepage gradually increased, and lands which had been tillable for cereals and root crops became unsuited for such crops and were pla[nted] to grasses for hay. The tame grasses were driven [out] a few years and water grasses of little value p[re]. In the beginning the areas affected were small, b[ut] continued to spread and creep up to higher [le]. the typical manner, until few farms were unaff[ected].

It was noticed that when the fields upon th[e] bench, one-half to three-quarters of a mile distan[t] irrigated the soil water appeared at the lowe[r] about thirty-six hours later. This indicated th[at] primary cause of the wet condition of the lower [fields] was seepage from the more elevated fields. Obser[vation] later established the fact that the water passed t[hrough] the soil along the line of greatest surface slope u[ntil] reached the lower sections, where it accumulated. [Owing] to the soil structure the ground water passed [more] readily through some parts than others, thus givi[ng the] water an uneven distribution, causing wet spots [rather] than a uniformly saturated condition of fields, as [ordi]narily might be expected.

Work was begun at Hyde Park during the summ[er] of 1904.

Plans and Construction.

A branch of 8-in. and 6-in. tile laid along the u[pper] edge of the wet land was designed to intercept [the] seepage from the lands above, and a 5-in. lower br[anch] was planned to furnish an outlet to the seepage w[hich] passed the upper line. These two lines discharged at their junction into an open ditch which gave much trouble on account of the banks caving in. Owing to the obstructions in the ditch the tile lines were kept full of backwater and consequently did not work properly. During the season of 1905 a 10-in. outlet was laid.

The construction work, except surveying, was done by the farmers. Preparatory to laying out the lines of tile a preliminary level survey was made. This work was simple, consisting of levels at important points, and

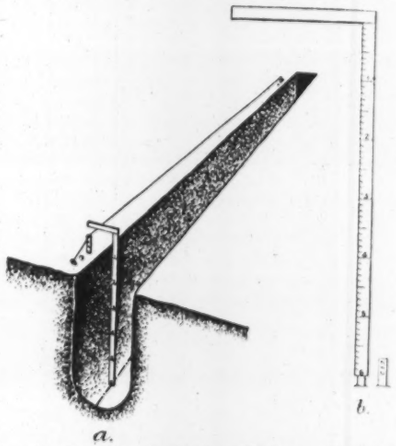


Fig. 1. Method of Grading Drainage Trench on Garland Tract, Utah.

was made by two men in an hour or two. With the figures thus secured, it was easy to stake the lines with assurance that the depths and grades would be satisfactory. In this and following work two sets of stakes were driven at 50-ft. intervals and 6 ins. from the edge of the trench. The stake from which the elevations and profile were determined was driven until the top was flush with the surface. The other, a 1-in. by 4-in. by 18-in. stake on which the station number and cut were marked, was set near the grade stake as a guide. Grade was obtained at each station by measurement and between stations by the flow of water. The grade of the bottom made in this way was more or less irregular, but on the whole fairly good, as indicated by the flowing water.

The soil generally was firm and would stand well after trenches were opened, so that the water method of grading, with measurements every 50 ft., was sufficient if followed with care. When the trenches were dug it was noticed that the water entered freely through crevices and channels in streams, some as large as a lead pencil. The subsoil, a granular clay, is somewhat stratified and sufficiently open to admit the moderately free passage of water. On the whole it may be regarded as a soil for which tile or other underdrains are suited, as there is sufficient clay to keep the soil compact. A few small pockets and other soft spots were encountered in parts of the fields outside of the experimental tract, and boards should have been laid under the tile in these places to insure proper alinement. Neglect to take these precautions resulted in failure in one place. The tile were laid by a man in the trench, and were blinded or carefully covered with a foot of soil as soon as laid. This is necessary to prevent displacement when filling the trenches by plowing, as is usually done.

*Condensation of Farmers' Bulletin No. 371, U. S. Dept. of Agriculture, issued Oct. 2, 1909. Descriptions of many small drainage works are given in the Bulletin in addition to those reported here.

†Drainage Engineer, Drainage Investigations, Office of Experiment Stations, Salt Lake City, Utah.

‡For furher details of the Utah work see Utah Sta. Bul. 99.

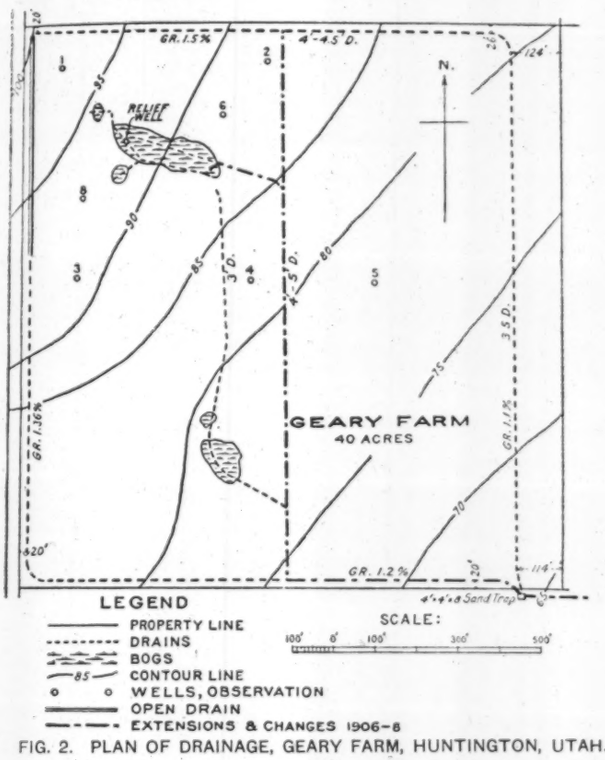


FIG. 2. PLAN OF DRAINAGE, GEARY FARM, HUNTINGTON, UTAH.

COST.—Excavating the trenches cost 40 cts. per rod for the smaller and 52 cts. for the larger trenches, where the depth did not exceed 4 ft.

The following table of costs is given for the experimental drains and charged to the experimental tract, which is approximately 31.5 acres. The cost per acre was greater than if the whole tract which was actively affected by the drains were considered.[1] The effects of these lines reach to one-quarter of a mile down the slope.

Tile:	
1,000 ft. of 10-in. tile, at $182.50 per M. ft.	$182.50
1,012 ft. of 8-in. tile, at $120 per M. ft.	121.14
330 ft. of 6-in. tile, at $60 per M. ft.	19.80
650 ft. of 5-in. tile, at $58 per M. ft.	37.70
2 6-in. on 8-in. wyes, at 72 cts.	1.44
	—$362.88
Hauling, digging and laying:	
Hauling tile, 30 tons 1½ miles, at 30 cts. per ton-mile	$13.50
Digging 134 rods, at 52 cts. per rod	69.68
Digging 42 rods, at 40 cts. per rod	16.80
Laying tile	18.75
Filling trench	10.00
	—$128.73
Total cost	$491.61

The average cost per acre was $15.60. The above costs were based on ten working hours per day, with labor at $2 per day, tile layers $2.50 per day, and man with team $3 per day.

RESULTS.—The land has been well drained and is yielding abundant crops. The owners reported yields in 1905-6 which were high for land in the best possible condition. Since drainage, 50 bushels of wheat and 100 bushels of oats per acre have been grown on the reclaimed land. The yield of beets for 1906, on drained land, was 18 tons per acre. The draining of this strip, only one-quarter of a mile wide, has made it possible to break the sod on an equal strip below and to again grow crops there. With the exception of the farmers who were interested in this work but very few are attempting drainage in other fields.

OBSTRUCTION OF TILE BY ROOTS.—It has long been known that the roots of certain water-loving trees, such as willows, would enter covered drains through the joints and small openings and branch into water roots many feet long, so numerous and close together as to fill the tile, thus obstructing the flow of water. It was also learned by these investigations that alfalfa roots were equally troublesome after a few years. During the fall of 1907 the ground water rose to the surface over [a portion of] the drains. The beets which were planted in the fields turned yellow and the ground became so soft that harvesting the crop in that condition was out of the question. Upon removing some of the tiles it was found that they were almost completely obstructed by beet roots. About half of the tile was removed, after which the balance was cleared of roots, and in a short time the ground was dry. During the last season, with the beets removed from about 2 ft. on each side of the trench, no trouble resulted.

Setting Grade Stakes on the Garland Tract.

The matter of properly setting guides for grading the bottom of the trench gave some trouble. With the hope of making the method for grading clearer, the following explanation is offered. Two sets of stakes are used, as at Hyde Park, one a grade stake driven to the surface of the ground, from which the levels are taken, and the other a guide stake, on which the cut for that particular station is marked. The stakes should be set about 1 ft. from the edge of the trench. The long one should be long enough to be driven about 1 ft. into the ground and leave about 2 ft. above ground. Fig. 1a shows the stakes in position, with a wire or string stretched across the tops of the guide stakes parallel to and just 6 ft. above grade. The guide stakes have been driven until the tops are above the grade stakes an amount equal to the length of the measuring bar minus the cut at the station. If the measuring bar be graduated, as shown, from the top down, the guide stakes may be set by driving them down to a level of the cut reading on the rod when the rod rests on the grade stake, as in Fig. 1b. With the rod held vertically, the lower end is at true grade when the horizontal arm touches the wire.

Huntington Experiment.

The work was begun in 1904, by making soil water observations at Huntington, and continued the following year by some construction. This office and the state cooperated with the Bureau of Soils, Emery County, and Mr. E. L. Geary in making an experimental test on the farm of the latter.

This tract was typical of the lands of the valley, and

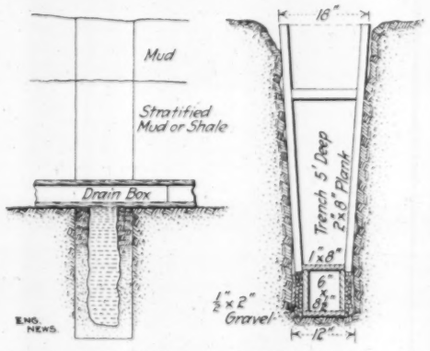


Fig. 4. Relief Well and Method of Laying Box Drain Through Soft Ground on Geary Farm, Huntington, Utah.

contained portions in all the varying stages of deterioration. The soil survey also showed that white alkali, ranging from less than 0.2% up to 3%, existed in the surface foot and to 6 ft. deep. For the location of the Geary farm, with reference to the surrounding fields, see Fig. 2. Preliminary examinations of this farm were made, including a thorough subsoil survey by means of test pits, auger borings, and probings with a steel rod to a depth of 15 ft. The subsoil survey brought out the relation of the shale hardpan to the source of the water and alkali. This formation lay in ridges and knolls under an almost uniformly sloping surface. The two bogs shown on the farm map were directly over two of these shale knolls, and it was shown that these carried to the farm, from some distant source, water highly charged with alkali. Some lateral seepage came from neighboring farms, but the bulk of the water which kept these bogs miry for rods around and which kept the soil saturated, was undoubtedly from the first source. Water stood on the surface within a few feet of a deep gully or arroyo on the south of the farm. It was clearly evident from this and other indications that the intercepting method of drainage would be necessary.

Plans and Construction.

Drain tile for covered drains was out of the question, on account of high freight rates and the distance from the railroad. Lumber was the next best material, and as this could be readily obtained it was chosen. Boxes were made of 2 × 12-in. plank for the outlet, and of 1 × 8-in. boards for the laterals, without bottoms in firm ground, and with bottoms for soft ground. (See Fig. 2.)

A line was cut into the bogs with the object of catching the water at a safe depth below the surface and conducting it away from the field. The upper drain of the central areas, shown on the farm map, was the first one constructed. The outside lines were laid as a protection against lateral seepage.

Some of the trenches were dug before the lumber arrived, and a heavy rain storm did considerable damage by causing the sides to cave in. About half of the digging was in such bad condition that it was impossible to get the boxes laid as deeply as planned, and in several cases the mud was pressed into the boxes continually. Flushing them with water was useless, but by cutting

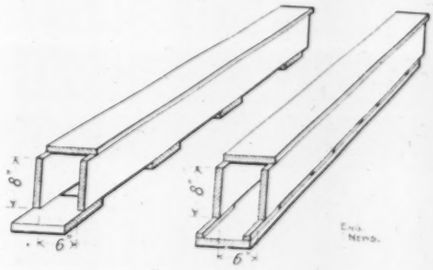


Fig. 3. Box Drains With and Without Bottoms, Geary Farm, Huntington, Utah.

the boxes into short sections and keeping them laid and covered to within a few feet of the digging, some headway was made. The boxes were laid about 3 ft. deep between the bogs, making it possible to get into the upper bog 6 ft. deep. Here considerable water was encountered and from a well 4 ft. deep (see Fig. 14a) in the bottom of the trench enough water rose and ran into the drain to give a head of 1¾ ins. over a 6-in. rectangular weir. This stream has been constant and the total discharge of the system has been nearly constant, except when affected by immediate irrigation. The discharge was measured at the outlet for a year, and gave an average head of 1-in. over a 12-in. rectangular weir and is still running. Most of this comes from the bog holes, and is highly charged with alkali. When nearing the bogs every contrivance failed, and water was turned in the trench to cut out the soft muck, which was run out over the field below.

COST.—Where the ground was dry or firm and the depth not over 4½ ft., digging cost 40 cts. per rod. Greater depths, up to 5½ ft., cost 55 cts. per rod. The digging in shale was heavy work, and cost as much as $2 per rod for short sections. The average cost for the first central line, including shale and very soft mud, was approximately 90 cts. per rod.

The cost of making boxes with open bottoms was about 10 cts. per rod. Boxes were laid and blinded for 20 cts. per rod, and filling cost approximately 8 cts. per rod.

The total cost of $808.67 works out 11½ cts. per lin. ft. and $20.21 per acre for the tract, though there is almost half as much more land drained outside of the field.

EXTENSIONS.—A portion of the west-side drain protecting the northwest corner became obstructed during the winter of 1905-6 and attempts to remove the obstruction proved unsuccessful. This section of the drain had been provided with boxes open on the bottom. Straw was thrown in the bottoms of the trenches before laying the boxes for the purpose of preventing the soft mud from squeezing into them. It seems that the weight of the soil caused it to flow into the boxes in spite of the precaution taken. As it was impracticable to remove these boxes, Mr. Geary decided to cut an open ditch, paralleling this section, between it and the fence. This ditch was washed to about 5 ft. in depth; and plans were made for laying boxes in the same, providing bottoms for the boxes and filling in the sides with gravel. (See Fig. 4b.) The laying of boxes in this section has not been finished, owing to other troubles.

During the same season (1906) a change in the central line for conducting the water away from the bogs was planned and late in the same year was partly finished. The necessity of putting another line through here was due to the shallowness of the first central drain. When this first line was laid it was impossible to get the boxes to a greater depth between the bogs

than 3 ft. This depth was not sufficient to prevent excessive evaporation along the line, but the drainage of the bog had dried out the land below, so that digging 5 ft. deep was now possible. It was decided to put in this line, as shown on the map (Fig. 2), in about the center of the farm, with the object of providing a better outlet and diverting the water from the upper bog into this drain. This line was completed out to the bend immediately below the bog.

No further work on these extensions was done during the year 1906, and cropping operations were carried on during the summer of 1907. A greater part of the farm was planted to oats, and care was taken in irrigating to prevent any washing by surface water. Irrigation was carried on immediately over the drains on the south side. The surface water was kept out of the drains during irrigation, but the soil continued to run into the boxes for several days after the application of water, resulting in the complete obstruction of the drains. These obstructions caused the drainage water which was coming from the two bogs to rise to the surface and to seep away into the soil during the balance of the summer. There was no other outlet for this water, so repairs were undertaken in May, 1908.

Subsequently, all boxes were provided with bottom boards (leaving openings of ¼-in., as in Fig. 3) and packed with sand and gravel along the sides. As it was impracticable to dig a new line anywhere near these portions on account of the excess of water, an attempt was made to uncover the boxes on the south side of the farm by using surface water and washing the earth through the outlet ditch into the large arroyo below. This attempt resulted in obstructions forming in the outlet drain which made it necessary to uncover these boxes and remove them. After washing out the soft mud and providing an outlet for the drainage water, work on relaying the boxes was resumed. Boards 1 × 12 ins. were nailed onto the bottoms of the outlet boxes, and they would have been relaid in the original outlet line had not the owners on the south proposed to cut an open ditch running east from the southeast corner of the Geary field to the county road. An outlet for the drainage of this system was offered, and 200 ft. of boxes was laid along that line as a precaution against erosion of the ditch in to the Geary farm. The balance of the closed boxes from the outlet line were laid on the south side. A new drain was constructed between the south side and the new central-line work laid in 1906. The necessity for this change was caused by an obstruction in the short diagonal section. After finishing the south-side repairs the completion of the central line was taken up. This line was extended through to the north side to protect the land below and to furnish an outlet through the reconstructed drain for water coming from the northwest side. The line extending northwest into the bog, with a branch for cutting the water of the upper drain over into the lower drain, was next taken up. All of the work done during the season of 1908 was under very difficult and discouraging conditions. The expense has been unusually high, and the complete reclamation of the tract is not yet attained. Three-fourths of the farm was planted to oats and a fair crop grown on possibly half of the farm. The barrenness of this field is slowly but surely giving way to improved conditions.

The total cost of making these extensions and repairs, including the work in 1906, was $557.45. This gives a cost per acre of $13.94, which, added to the original cost of $20.21, makes $34.15 per acre up to date.

In conclusion, it may be safely said that unless special precautions are taken in limiting the openings and protecting the same by gravel and sand, the use of covered drains in these soils will not prove very satisfactory. In addition to these precautions, irrigation must not be carried on directly over the drains, and where irrigation ditches must cross the drainage lines flumes should be provided. There is no question that this farm has been greatly improved, as evidenced by its appearance and the crops now growing. The obstructing of the drains and consequent rise of ground water on the south side of the farm also injured the Johnson tract on the south. The cost has been higher than land values would warrant in this particular case, but there is every reason for believing that success within the proper economical limits will be attained.

Drainage of Irrigated Lands in Other States.

Passing to other states, it should be noted that irrigated land has been successfully drained by some one of the methods employed in Utah. Some of the wet lands about North Yakima, Wash., have been reclaimed by underdrains placed diagonally across the slope at a depth of 5 ft., in such a manner as to intercept the underflow from the higher lands, which are so largely underlain by gravel as to permit a ready flow of soil water to lower lands. These drains are discharged into receiving drains, either open or covered, which lead the water to some natural stream. Where the construction of the intercepting ditches has been omitted the land has not been satisfactorily drained.

The well system has proved valuable and often efficient in sections of Colorado, where the gravel which supplies the water lies 8 or 9 ft. below the surface, and also in some instances where the loose loam soil rests upon a stratum of hard clay. Wells of any convenient cross section are excavated to the water-bearing stratum, from which a tile or box conduit, laid about 4 ft. deep, leads the water which rises in the well into a receiving drain.

Where the land is level and the soil fine and homogeneous in character, like that near Fresno, Cal., it has been found best to lay underdrains about 6 ft. deep directly through such lands as are affected by seepage and alkali. These collect soil water from a considerable distance on either side by ordinary percolation and deliver it into a sump, from which it is pumped into surface ditches. The difficulties which attended the construction of the drains in the Fresno district were similar to those described elsewhere in this bulletin. It has been found necessary to observe the same precautions in the subsequent management of both drains and fields as is found necessary in Utah.

Principles and Practice.

LANDS NEEDING DRAINAGE.—Irrigated lands needing drainage may be divided into three classes:

(1) Those injured by excess of water only.

(2) Those affected by an excess of both water and alkali.

(3) Those having an excess of alkali only.

The first class is the least extensive of the three, the extent of injury depending upon the value of the crops that may be grown on the land when dry. The greatest danger of serious loss in this kind of land is that alkali may accumulate in injurious quantities with the lapse of time. In the irrigated region there is very little seepage water which does not contain some alkali in solution, which tends to accumulate to an injurious degree in saturated land. Inquiry into the history of lands which have become badly affected with both alkali and water show that when injury first became noticeable such lands could have been protected from further injury with as much profit as attended the reclamation of lands affected by water only.

It is to the second class that most of the lands belong which now need drainage in the irrigated sections. Alkali accumulations usually follow accumulations of seepage water. If one admits that this condition is a forerunner of total abandonment, surely no argument is necessary to convince him that such lands belong to the class that should be drained.

Lands of the third class are principally those in the virgin state, having enough alkali uniformly distributed through the soil to a depth of 6 ft. to cause crop failure after a few years of irrigation, because of insufficient underdrainage. The lowlands of Millard and some of those in Salt Lake, Weber, Boxelder, and Emery counties, Utah, belong in this class. If irrigated lightly, the alkali will in time become concentrated at the surface, and if irrigated copiously, without underdrainage, waterlogging will follow.

ALKALI AND GROUND WATER.—The relation of alkali to drainage is important and must be taken into account. In speaking of alkalies in his book on "Soils," Hilgard says:

> They are the natural result of a light rainfall, insufficient to leach out of the land the salts that always form in it by progressive weathering of the rock powder, of which all soils largely consist.

Ordinarily alkali is made up of one or more of the following salts in varying proportions: Sodium chlorid (common salt), sodium sulphate (Glauber's salt), magnesium sulphate (Epsom's salt), calcium chlorid, and calcium sulphate, all of which are white alkalis, and sodium carbonate (sal-soda) or black alkali. The latter is so called on account of the dark stains on the ground caused by the dissolution of the soil humus or vegetable matter. These salts and also the mineral plant foods are readily soluble in water, so that in the humid countries the constant leaching removes not only the injurious salts but also part of the plant foods. This accounts for the intrinsic fertility of the arid lands as compared with humid lands. The account of the origin of alkali naturally suggests the control by irrigation and underdrainage.

Of the fundamental principles, those relating to ground water and its movements are perhaps the most important. There is no question that seepage is an actual accompaniment of all irrigation. It has been found in all irrigated countries, doing damage and requiring drainage. The sources of supply are leakage from canals, surface applications, and precipitation. If the soil has the capacity for discharging this water as fast as it is supplied no damage will be done. If, on the other hand, more than its capacity is supplied trouble will surely follow. Soils in the Bear River Valley, Utah, having a depth of 40 ft. and a fair surface slope have been known to fill after 15 years of irrigation until water rose to the surface, doing considerable damage.

A proper appreciation of seepage conditions often involves a knowledge of the ability of water to transmit pressure between two points, due to differences of elevation. This is often manifested in irrigated sections by ground water springing up through the innumerable soil pores. Such a condition indicates a porous substratum filled wth water exerting a pressure. When the stratum is too deep to cut into by a drain, [illegible] wells connecting with the drains at an ordinary [illegible] afford the best solution.

Another physical property affecting the move[illegible] of ground water and of great importance is that ca[illegible] pillary attraction. This phenomenon was named [illegible] the inherent ability of liquids to rise in small hair[illegible] of capillary tubes above their free surfaces. Wat[illegible] rises higher in the tubes and also in soil particles th[illegible] any of the other liquids. This property is most esse[illegible] to plant life and crop production, but uncontrolled [illegible] line soils it hastens the accumulations of alkali [illegible] surface. In soils varying from coarse sand to ve[illegible] clay, water will rise by this attraction from 2 [illegible] ft. When the surface is allowed to become hard and [illegible] as when abandoned or allowed to stand idle, a s[illegible] tension is formed which increases this attraction an[illegible] consequent evaporation. It is the evaporation of [illegible] quantities of water containing alkaline salts in so[illegible] that does the damage. The evaporated water pass[illegible] nearly free, leaving the alkali in the surface soil. [illegible] periments have shown that of the water applied in [illegible] nary irrigation, without cultivation, from 30 to 50 [illegible] evaporated from the surface. If, in addition to this, seepage water from higher lands or canals contai[illegible] much alkali is within reach of capillary attraction, and the surface poorly cared for, thus increasing evapora[illegible] tion, alkali accumulations surely follow. A minimum depth of 4 ft. for drains, with cultivated or shade crops, has been the practice of the drainage engineers of this office, though deep drainage from 5 to 6 ft. is preferred.

PLANS FOR DRAINAGE.—The soils of the arid regions have not been subject to percolating water since their formation, as the humid soils have been, and consequently are without the drainage pores of the latter. If they have any water pores at all, they are those of the water doing the damage. The water applied to the higher lands affects the lower lands, where it flows out or comes near the surface, whether in light or heavy soil. In moving laterally through the body of the soil the water will flow along the lines of greatest slope and will not drain well into tile lines parallel to its movement. The drainage water in all of these experiments has found its way through some special underground passage, or stratum, or some modification of these, rather than uniformly through the soil. The experiments in Emery and Weber counties were particularly examples of the flow through some special underground passages, while the others were modifications. Conditions similar to those in Emery and Weber counties were observed in Paonia and Delta, Colo. At both of these places the efforts to drain the land were proving unsuccessful. These and a dozen other illustrative examples may be cited where special treatment was necessary; but those named are enough to show that the method of intercepting the water as it enters the field or soil, either by lateral seepage or some lower passage, is highly essential to success. However, intercepting drains are not all that are necessary. In nearly every instance outlet lines through the lowest wet portions are absolutely necessary, as is the case in humid sections.

Before drainage work can be taken up with any surety of success these underground conditions must be determined. If expensive mistakes are to be avoided, the subsoil examinations must not be neglected. The first method of making such examinations is that of digging test pits. Under ordinary conditions a depth of 6 ft. can be reached without any difficulty. The test pit is also valuable for showing the nature of the digging for which special methods may be necessary. Another method is to use a soil auger, made of a 2-in. wood bit and ½-in. gas pipe, with which holes can be put down 12 ft, if gravel is not present. A long steel rod probe ⅝-in. in diameter can often be used to advantage in soft ground.

The kind of drain to be employed in farm drainage will be determined largely by local conditions. Open ditches are sometimes used for farm drainage, but more often for outlet and main drains. The principal objections to the use of open ditches for farm ditches are the loss of land and the high initial cost if sufficient side slope is given them. If side slopes are left steep the maintenance expenses are high.

Covered drains may be divided into the following forms: Tile, lumber boxes, stone, brush, and mole-plow drains. Burned clay tiles, chiefly in a round form and in 1-ft. sections, have been in use for more than four hundred years and have proved satisfactory. They have been known to endure for one hundred years. Some kinds of clay tile, when left upon the surface of the ground, will be disintegrated by soil alkali and by freezing. The old idea that tile should be porous has been abandoned.

If farm drains must be laid along lines of water-loving trees and within 100 ft. of them, the drains should be open ditches to prevent roots from obstructing them. The need of covered drains in orchards requiring drainage has necessitated a method of removing the roots without removing the tile. In California, cables are strung through the tile and root brushes pulled through short sections. A similar method was also

employed in the Point Lookout experiment, as previously mentioned.

The questions of locating the lines and determining their sizes and depths will have to be determined by judgment, applying the fundamental principles herein stated. No general directions, such as a gridiron, double main, and single or parallel systems, commonly used for drainage in humid districts, can be given for this kind of drainage. Such systems, with parallel lines 1 rod apart, might fail entirely if applied to some irrigated fields. If after careful examination the trouble is located as lateral seepage, a single line should be laid across the line of greatest slope 2 to 6 rods below the upper line of the wet spot. Such spots are usually small and one line may be sufficient, but an outlet line or branch should be laid through the low ground or basin. The distance down the slope affected by a drain will vary from 300 to 2,000 ft., according to local conditions. If the source is found to be in particular spots, as at Huntington, Emery County, a branch for each spot will be necessary. Wells as outlets for water-bearing porous substrata should be located at the end of the pocket if it pinches out, and on the lowest ground if it extends all the way under the tract.

Lateral and main outlet drains should be clear to a depth of 5 ft., especially if they are intended for farm outlets on such land. The depth of covered drains for arid soils is determined by two factors. The first is the depth of the drained soil necessary for different crops. For grasses and cereals a soil depth of 3 ft. is sufficient. Fruit trees and alfalfa should have from 5 to 6 ft., and still greater depths are advantageous. The other factor in alkaline lands is capillary attraction. The height to which water will rise and evaporate in large quantities is the minimum depth allowable for ground-water level. Generally the water should be kept from 4 to 6 ft. below the surface to satisfy these requirements. The minimum grade is 0.1% and may be increased to as much as 5% if necessary. Sizes from 4 to 6 ins. will be sufficient for laterals in clay soils, with larger sizes for coarser soils. A study of the plans given in this bulletin will show that fewer drains are needed in the irrigated sections than in the humid.

Plans for drainage other than small, inexpensive lines should always include surveys. Level surveys, both preliminary and final, are absolutely necessary. The need of surveys for expensive tile or open ditch work ought not to be questioned. The enormous losses to farmers and cooperative companies in the past, when constructing irrigating works without competent engineering supervision, should be a lesson, and similar mistakes should not be repeated in undertaking expensive drainage works. At the time when final surveys are made the lines should be tied up to or located with reference to permanent marks, and a map of the system made. Such a map may prove valuable in planning future extensions and in other ways, when otherwise the exact location would be forgotten.

FIELD CONSTRUCTION.—The tools most used for digging trenches are trenching spades, shovels, and tile scoops. Tile trenching machines are being introduced, but the chief dependence for this work will be hand labor. The digging for farm drains should always begin at the outlet, finishing the work as it proceeds, except completing the backfilling. For trenches not deeper than 5 ft. and for sizes of tile up to 12-in., the top width need not be more than 18 ins. To insure proper alinement one side should be lined for the first spading. The last 16 ins. should be removed in the last spading and the bottom graded at the same time. The work is much more easily done this way than if the digger were lower in the trench, and the bottom will remain firmer if not mushed up by constant tramping. Very few trenches can be finished in the irrigated districts without the trouble caused by the banks caving in, so that it is necessary to keep the tile laid and the trenches partly back filled up to within a few feet of the finished trench, and for that reason two or three diggers with one tile layer make the best team. With proper care the grade should only vary within one-fourth inch of true grade.

Laying tile is an important part of the proper construction of drains, even when the trench is made straight and on a uniform grade. The first item of importance is providing a firm foundation on which to lay the tile. In irrigated lands there are often soft spots which need some special treatment. The best method in such cases is to lay long boards in the trench upon which to lay the tile. If some such precaution is not taken one or more tile may settle or be pressed out of alinement and form a complete obstruction. When laying tile through an orchard with the intention of operating a brush or root cutter, boards with cleats on each side to hold the tile in true alinement are sometimes used. Tiles are not always cut off squarely, and when laid they should be turned until the tops set closely together, leaving the bottoms open for water. The ground should be firm enough to hold a man on a blinded tile, and the tile layer should work from the tile, if need be. Tile should always be carefully covered or blinded, as it is called, as soon as it is laid; and, for safety, the trench should be back filled enough to prevent the banks from caving in. Sand-trap boxes should always be put in at intervals of 300 to 500 ft., when fine sand or silt troubles occur, and also in orchards. These may be used as inlets for water when flushing tile or boxes.

After the tiles have been blinded and the trench partly filled by hand, the balance of the filling may be done with horses and plow. Three horses and a long evener are used for the first plowing. This plowing should be from the edges of the trench, after which a team may be used, one horse walking in the trench. It is not necessary to fill loosely so that the water may get into the tiles. Tramping and tamping are necessary to prevent surface water from entering and doing much damage. For the same reason, all brush and weeds should be removed, and not used for filling. The plowing should be continued until a heavy back furrow is worked up over the line.

SUBSEQUENT CARE NECESSARY.—Attention to drainage should not cease when the system is installed. Upon the subsequent care and treatment of the drains and drained fields will depend the final efficiency. One of the greatest sources of trouble, in covered drains especially, has been the damage resulting from surface water running into the trench. In some soils it has been necessary to place boxes or flumes for carrying irrigation water over trench lines to keep the water from finding its way down through the loose soil to the drain with resultant obstructions. These troubles occur in sandy and silt loams but not in clay loams. Tree and brush roots cause much trouble by growing into covered drains in search of water, and then developing enough water roots to seriously interfere with the flow of water. Alfalfa roots will also cause obstructions in tile after several years, and the report of the Hyde Park experiment (Cache County) contains an account of serious troubles caused by beet roots. To prevent excessive evaporation the proper cultivation of the surface is necessary. As explained before, a hard, smooth surface increases the evaporation of soil moisture. Where possible such soils should be cultivated after each irrigation so as to form a mulch on the surface. Shade crops, such as alfalfa, are also useful in preventing evaporation. Cropping and copious irrigation are absolutely necessary for reclaiming alkalied lands after underdrainage is supplied.

COST SUMMARY.—The cost of draining the lands described in these investigations is the basis for the statement that such lands can be profitably drained. The Hyde Park lands, formerly only fit for pasturage, were drained at a cost of $15.60 per acre. During the two following years different portions were planted to oats, wheat, and sugar beets. The yields were 100 bushels of oats, 50 bushels of wheat, and 18 tons of sugar beets per acre. The Garland wet land was drained at a cost of $16.87 per acre, which raised the land value from less than $100 to $150 per acre.

The Getz farm at Point Lookout, which was badly alkalied and produced practically nothing, was drained, producing 35 bushels of oats per acre the following season. The Hobson farm at Roy, Utah, was drained at a cost of $13.67 per acre, which enhanced its value $25 per acre. The Richfield tract is well drained at a cost of $14.02 per acre, and the land, formerly worth $25 per acre, promises to reach the $100 mark. Lands in Weber and Davis counties, valued at $150 to $300 per acre, have been preserved by draining at about the same cost as those above mentioned. The Huntington and St. George tracts are not yet reclaimed, but it is expected that the cost of reclaiming such lands, according to methods now in use, will fall within or close to the highest costs given here.

An Important Consolidation of German Electrical Companies.

In Engineering News, Feb. 4, 1909, p. 129, it was noted how the operations of the numerous German electrical manufacturing concerns had been consolidated until four large and important distinct interests had resulted. At the close of a period of great prosperity, in 1900, there were seven large electrical manufacturing concerns: Siemens & Halske, the Allgemeine Electricitats Gesellschaft, Schuckert & Co., the Union Electricitats Gesellschaft, the Helios concern, Lahmeyer & Co., and Felton & Guilleaume.

Siemens & Halske was founded in 1847 by Werner Siemens, who kept his concern far in the lead until Emil Rathenau achieved his great success. Rathenau is an engineer who became the owner of the Edison patent rights for Germany and founded the Allgemeine Electricitats Gesellschaft in 1883, which a little later became independent of the American holding company and took up all lines of work. Rathenau, though now 70 years old, still holds his place as president of this great concern. The firm of Schuckert & Co. was founded in 1873 by Johann Siegmund Schuckert, a former mechanic with the Edison company in America. The late Louis J. Magee, of New York, organized the Union Gesellschaft in 1892 as a branch of the Thomson-Houston Co. The Helios was a small company which bought the German rights for the Tesla patents and greatly extended its business. Lahmeyer & Co., originated, in 1893, from a consolidation of two small Frankfort firms. Felton & Guillaume were large makers of wires and cables.

The Allgemeine bought the Union; Siemens & Halske and Schuckert & Co. formed the Siemens-Schuckert Werke; Lahmeyer combined with Felton & Guilleaume. These three by mutual consent bought up the plants of the Helios concern and closed them down.

The Allgemeine Gesellschaft in 1909 probably employed some 35,000 men in nine factories. It has a working agreement with the General Electric Co., of Schenectady, N. Y., defining their activity in all parts of the globe; they interchange patent rights and experience and train a few of each others engineers.

The Siemens-Schuckert Werke has been considered fully as strong as the Allgemeine Gesellschaft; there are some 25,000 men employed and a great attempt is made to develop new lines. This is a limited liability concern manufacturing heavy machinery only. However, it is, except in name and form, part of the older Siemens & Halske Actiengesellschaft (joint stock company) which employs some 15,000 men, making the lighter and finer classes of electrical apparatus, like instruments, telephones and telegraphs, block signals, lamps, etc. This industrial combination has a close association with the Siemens Brothers Dynamo Works in England, which was founded by a branch of the same Siemens family.

These three leading firms employ about 50% of the men in the electrical manufacturing industries and control about 50% of the production. There are, however, some 275 other concerns, some of which are important. There is chief among these—or almost out of this class—the Bergmann Electricitats Gesellschaft which first made only conduit but has extended to other lines.

In recent foreign papers is noted the beginning of a further combination of the German electrical-engineering industries. It is reported that the Zurich Bank for Electrical Enterprises, which was originally formed as an investment and promoting concern by the Allgemeine Elektrizitats Gesellschaft, of Berlin, recently made an offer for an exchange of stock with a Lahmeyer Electric Co., which offer has been accepted. This Lahmeyer Co. holds $4,000,000 in stock of the Felten & Guilleaume-Lahmeyer Werke, so that it is seen that the Allgemeine Gesellschaft through the Zurich Bank for Electrical Enterprises has obtained an interest in the heretofore independent Lahmeyer concern, though not a controlling interest, as the capitalization is about $13,750,000.

It is also reported that on account of the unfavorable operation of the Frankfort dynamo works of the Felten & Guilleaume-Lahmeyer Co., in 1909 the disposal of this factory was sought. By some, the transaction just effected is regarded as preliminary to the acquisition of the Frankfort works by the Allgemeine Gesellschaft. In reality, the dynamo works are to be transferred exclusive of this in the form of a new company with a capital of $2,500,000 and a reserve of $750,000, for which new shares in the Allgemeine Gessellschaft are to be issued having a nominal value of $2,500,000 and a quotation value of $5,000,000. Even this transaction would not give over the dominating influence in the Felten & Guilleaume-Lahmeyer works, and in order to secure this position the Guilleaume family has consented to transfer $4,000,000 in stock to the Allgemeine Gesellschaft in return for a second block of new shares in the latter having a nominal value of $2,500,000. A third sum of $2,500,000 in new shares of the Allgemeine Gesellschaft is to be offered to existing shareholders at the price of 210% par to develop the Frankfort works. An interchange of directors between the principal companies in-

volved is to take place. The Felten & Guilleaume-Lahmeyer Co. will discontinue the use of the word "Lahmeyer" in its title, and will devote itself to the company's cable works and allied branches.

It is thus seen that the Allgemeine Gesellschaft seeks in a single move to increase its ordinary capitalization from about $25,000,000 to about $32,500,000, and its total nominal capital to about $45,000,000. It is generally believed abroad that the company has removed one troublesome competitor in the electrical-engineering field and has at the same time assumed a more prominent place in the cable-manufacturing industry. It also secures a factory in the south of Germany, where the Siemens companies have predominated. It is expected by many that the Siemens firms will be compelled to follow the example of the Allgemeine Gesellschaft and develop their commercial resources in order to be on equal standing. The only other firm of real importance in the electrical-engineering field is the Bergmann company, which may seek amalgamation with the Siemens-Schuckert Werke for mutual benefit. However, it is certain that the Siemens concerns feel that their position is still secure without further consolidation. It is generally admitted that while the Allgemeine Gesellschaft has greater commercial activity and ability, the Siemens firms are regarded almost as official manufacturers for the government, which is a large customer. Being largely dominated still by the Siemens family, these firms seek to maintain a technical leadership by developing new apparatus rather than to secure merely steady sales of stock designs.

Should the expected combination take place, the German industry will be mostly in the hands of two powerful groups, as may be said to be the case in America.

The Electrical Operation of Drawbridges.*

By S. F. NICHOLS.†

The development of the series-wound reversing electric motor placed at the bridge engineer's disposal a means of applying power to all forms of draw spans that is almost ideal. The first installations of electric motors for drawbridges were on highway bridges, commencing about 1890. The lake cities (Chicago, Cleveland, Milwaukee, etc.) having electric-power lines operating on their streets were easily induced to adopt electric power for their bridges. Railways were comparatively slow in adopting electric power for this purpose. Their bridges were not so fortunately located with reference to securing power. The great majority of the draw spans being at points remote from the larger cities, it was out of the question to consider electrical operation without the installation of an independent power plant. A very large percentage of the bascule bridges that have been built have been equipped with electric motors and controlling devices.

The electric motor has many points to recommend it, with few disadvantages. It is very light and compact, and it is very conveniently reversed. It is capable of sustaining a very heavy overload for short periods, which enables it to take care of the very difficult problem of accelerating a heavy mass and also of operating the bridge against high wind pressures that may occasionally be experienced. It is almost noiseless in operation. It requires comparatively little attention, and when periodically inspected the possibility of its getting out of order and refusing to work is very remote.

Being compact it can be located very close to the point where the power must be used. This makes it possible to locate the operator at the most convenient position from the standpoint of accessibility or where the best view can be obtained of the river or railroad or highway traffic. The motors can be located on a moving portion of the structure while the operator's house is located on the fixed part. This is one reason why the electric motor has been so important a feature in the development of the bascule bridge, as on a number of present designs the leaf motors as well as the motors operating the locks at the extreme point of the bridge, move with the leaf. Connection can readily be made between the moving and fixed portions of the bridge by means of swinging ropes, flexible joints or collecting rings.

BASCULE BRIDGES.—The modern bascule bridge requires the use of one or two motors for the operation of the moving leaf, a motor for the front lock, and in some cases a motor for the rail locks. Frequently, moving rail locks are omitted and the end locks are operated by hand power. Each of these motors is ordinarily provided with a solenoid brake, and the motors operating the end lock and rail lock are automatically stopped by the current being cut off and the brake being applied when the lock in its travel reaches the end of its motion in either direction. The current is ordinarily cut off from the leaf motors and the brakes applied when the leaf in opening reaches a point beyond which it is dangerous to allow it to travel.

The controllers for the several motors are located in the operator's house, and a switchboard is provided carrying the necessary instruments. The motion of the leaf is under the control of the operator at all times except when it reaches the danger-point limit in opening, when the automatic stop acts. The motors for the end locks and rail locks are ordinarily started in the proper direction and run continuously until automatically stopped by the action of the contact switches which cause the rupturing of the motor circuit at the switchboard. The positions of the bridge leaf and locks are shown to the operator by means of indicator lights conveniently grouped in front of the controller.

Owing to the fact that all the motors are on the moving leaf, it is not usually found feasible to install a mechanical brake and in order to avoid the possibility of disastrous results attending the failure of the motor brakes to hold the leaf, it is customary to install an emergency brake which will be applied automatically in case the current fails; or it may be applied by the operator if desired. This brake is set by springs and ordinarily pulled into release before starting the bridge, and is applied again after the swing is made, not being used as a service brake, unless the emergency conditions arise.

An electric solenoid has frequently been used for the purpose of releasing this brake in the past but a better method has been found in the way of a small electric motor operating a mechanism for releasing the brake, and holding it in release as long as the current is held on the motor. Rupturing the circuit by the operator or by the loss of current on the line automatically trips a release and insures instantaneous application of the brake without waiting for the mechanism to go through the reverse motion corresponding to that in releasing.

SWING BRIDGES.—The equipment for a large swing bridge is somewhat more elaborate than that for a single-leaf bascule bridge owing to the necessity of having a powerful lift or wedge mechanism at each end of the bridge, and the fact that some form of moving rail lock is necessary. In addition to the motors required at the center for swinging the span, a motor is necessary at each end for the lift or wedge mechanism and an additional motor is usually necessary at each end for the rail locks for the single or double track, as the case may be. On the ordinary swing bridge it is perfectly feasible to use a mechanical brake, so that the electric motor brakes and emergency brakes for the swing may be omitted. The operation and control of the wedge motors and rail lock motors is the same as on the bascule spans.

INTERLOCKING CONTROL.—The operator has before him a few small levers, the indicators and the switchboard equipment. Unless some provision is made to prevent it, it is possible for him to attempt one operation before another is completed and thus wreck the bridge, or bring disaster to traffic. To avoid this possibility, a system of electric interlocking has been developed so that the control of each motion in the entire operation of the bridge shall be completely interlocked with the next preceding (and with the next succeeding one, if any), and with the railway signals, in such a way that current cannot be turned on any motor until the preceding motion has actually performed.

In opening, it is impossible for the operator to turn current on to any of the motors on the bridge until the signals and other protecting devices have been set against trains. It is impossible to operate the wedge motors until the rail locks have been drawn or to operate the swing motors until the rail locks and wedges have both been drawn.

In closing, it is impossible for the operator to drive the wedges until the span has been swung and is closely enough in line to allow the wedges to be safely entered. It is impossible for the rail locks to be driven until the wedges have all been entered, or for the operator to clear the signals, for the passage of trains until all of the wedges and all of the rail locks have been fully driven.

This electric interlocking is accomplished by the circuits of any one device being held open at all times on a contactor board by the other devices until [illegible] proper time for its safe operation. When the other [illegible] preceding the desired operation have actually [illegible] completed, the circuits are restored, so that the [illegible] motion can be performed by the operator [illegible] the proper controller. The same indicator switch [illegible] several devices are ordinarily used for both [illegible] indication and electric interlocking, and to as [illegible] an extent as possible, the same circuits are [illegible] for the two purposes.

Very little attempt is made at electric [illegible] railway structures beyond the illumination of [illegible] ator's house and providing a sufficient numbe[illegible] openings near the several machinery parts. Th[illegible] ment requirements also have to be complied w[illegible] necessitate having red lanterns on the pier[illegible] specified points on the movable spans. On th[illegible] bridges it is required that the red lights at [illegible] ends of the bridges be changed to green [illegible] bridge has nearly reached the open position. [illegible] sometimes accomplished by swinging a lant[illegible] behind a red glass to a position behind a gr[illegible] as the bridge reaches its nearly open position. It is preferably performed by the use of a double lant[illegible] extinguishing the red and lighting the green by [illegible] contacts in the leaf indicator switch.

POWER GENERATING PLANTS.—The adoption of electric power for the operation of drawbridges has usually been contingent upon being able to secure direct current at the standard voltages or two-phase or three-phase alternating current at 60 cycles or 25 cycles. The electrical operation of many important drawbridges, however, is so desirable that even the impossibility of obtaining electric current from existing power plants for 24-hour service should not deter engineers from its adoption.

The improvements in gasoline engines have made it possible to operate, to a good degree of economy, comparatively small isolated electric generating plants. Under this scheme two arrangements are possible. One is to have the generating unit of sufficient capacity to supply current direct to the several motors on the bridge as required. The objection to this scheme is that all of the motors on the bridge have a considerable overload capacity and are subject to overloads under a good many conditions. The gasoline engine on the other hand has practically no overload capacity other than momentary, and it is therefore necessary to use a large and expensive engine for a comparatively small current consumption. If it is necessary to install the generating plant on the bridge this means a large engine room and heavy floor construction to prevent excessive vibration.

Another plan is to install a storage battery of discharge rate high enough to take care of the operation of the bridge under the severest conditions, and of sufficient ampere-hour capacity to operate the bridge for at least 24 hours without recharging. The gasoline-driven generating unit in this case may be very small, the requirements simply being that it must be able to recharge the storage battery at the desired intervals, it not being necessary for it to supply current direct to the motors on the bridge.

A still better arrangement is a combination between the last two plans. This consists of the installation of a storage battery of a sufficiently high discharge rate to operate the bridge under the severest conditions of wind and weather and of sufficient capacity to give the bridge from 20 to 40 openings. The generating plant consists of two direct-connected gasoline engine driven units, the combined capacity of which is sufficient to operate the bridge independent of the storage battery, and either of which is available for the charging of the battery. The advantage of this system is that the bridge may be kept in commission even if the storage battery is discharged or out of service for any reason. It is also possible to charge the battery from either generating unit if the other is out of service from any cause. Furthermore, under extreme conditions it is possible to supplement the storage battery by using either or both generating units connected up with it for supplying current to the bridge. The generators and engines in the two units being duplicates, there is small possibility of both being out of commission at the same time.

In either case, the generating plant may be located either on the bridge structure or on shore. The latter arrangement is likely to require more attendants but has the advantage of providing a more stable support for the storage battery and a better foundation for the generating units. But it involves the use of submarine cables for supplying current to the bridge, if it be a swing span.

THE LARGEST WELDLESS STEEL RINGS OR shells ever rolled from solid ingots are said to be some rolled by the Interocean Steel Co., of Chicago, for use in crushing ore. Each ring is 54 ins. outside diameter, 20 ins. wide and 5 ins. thick, with a weight of 4,[illegible] lbs. They were forged under a 5,000-ton press and rolled in tire-rolling machines. Prior to this time the maximum width of ring was 16 ins., and as there was a demand for 20-in. rings these had to be made in two pieces.

*Abstract of a paper read at the annual convention of the Association of Railway Electrical Engineers, at Chicago, Sept. 27, 30, 1910. The first part of the paper points out the disadvantages of operation by steam and gasoline engines. For steam, the equipment was held to be very heavy, and as steam must be kept up all the time the cost per swing was held to be very high where the bridge is operated only occasionally. Gasoline engines, the author believed, must be kept running slowly (as it is difficult to start them promptly), and in service the vibrations would necessitate a very heavy floor construction. As the gasoline engine cannot easily be reversed, duplicate sets of clutches for forward and reverse movement are required. With both steam and gasoline engines there was held likely to be trouble with the end lifts and locks, due to the transmission of the power through a series of shafts and gears.—Ed.

†Old Colony Building, Chicago.

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The increasing necessity for the adoption of the block system on electric interurban railways having heavy traffic was discussed in our issue of Sept. 29, and a recent disastrous collision occurring under ordinary methods was cited as illustrating the argument. Since then two similar accidents have occurred, one of them being about as disastrous as the first of the three. These call attention forcibly to the defects and dangers of the system of train dispatching now employed on lines of this class, and to the need of a higher quality of operating service. Of course, even three such serious accidents, if considered alone, might not warrant severe criticism of the operating system. As a matter of fact accidents of the same kind, and due to the same causes, are of frequent occurrence, but as the results are rarely so serious, little is heard about them. The manager of the railway on which this latest accident occurred is reported as saying that "the dispatching system used is perfect."

But a fundamental imperfection of the train dispatching system is that it leaves each train crew to operate its train without check and without knowledge on the part of others. The crew is absolutely without control beyond an order written on a piece of paper, which order they may or may not understand, remember and obey. If a crew wilfully or carelessly passes a meeting point and succeeds in reaching the next siding without accident, nothing is likely to be heard of the matter. The crew which obeys orders is at the mercy of the one which disobeys, having no knowledge of the movements of the latter. In one of the recent disasters the motorman of the southbound train had for some time been running the northbound train which he had orders to pass at a certain point. Under his operation this latter train had been always late and assuming that it would be so in the hands of the other man he disobeyed orders and tried to reach the next meeting point. But the new man on the northbound train had managed to run on time, and consequently had passed this second point. With block signals, a crew would have visible (and perhaps audible) warning of danger ahead, and even a reckless man would hardly pass a meeting point when the signal plainly showed that an opposing train was between him and the next point. In the same way, the man waiting on the siding would not have to rely on his memory to show him that only one opposing train had passed when he had orders to wait for two trains.

There are two means of improving present conditions: by installing block signals and by double-tracking busy single-track line. But the railway companies are directing their energies almost entirely to the improvement of the rules and regulations, the system remaining unaltered. This seems to be extremely illogical, for the reason that officers generally admit a difficulty in getting men of proper capacity for the service and in enforcing discipline and observance of rules upon these men. There is a strong movement in favor of adopting the standard code of the American Railway Association, but in a letter to the "Electric Traction Weekly" the general superintendent of one of the lines which was the scene of a disastrous accident opposes these as being too complicated. He says:

> As yet there are not enough experienced interurban men to fill all the requirements of the different roads, thus making it necessary to take men of practically no experience, except, perhaps, a little street-car experience. This being the case, the class of men, as a rule, that make up the trainmen on interurban lines would not be able to digest a book of rules as comprehensive as the A. R. A. book would be to one not brought up through the usual way that steam road men are. This being the case, I do not see the necessity for other than the most simple book of rules that can be compiled.

It does not seem to have occurred to the superintendent that the men should be educated and disciplined to the extent of being able to comprehend orders which are of general application on steam railways. On the contrary, he believes in bringing the standard of the rules down to the level of the men. But this is practically an admission that neither the rules nor the men are up to the proper standard for the safe handling of traffic. One feature of steam railway rules which appears to be objected to with good reason by the electric lines is that of giving one train superior rights over another. The objections to this are the frequency of trains and the lack of proper training on the part of the men handling them. On steam railways men usually work for some years before reaching a position in which they will have charge of train movements, by which time they will understand the rules thoroughly. On the electric roads, this is not the case, and the men may not be competent to figure out how to keep out of the way of opposing trains of a superior class. The opinion seems to be that the better plan is to govern all passenger trains by direct train orders with meeting points. From a discussion of this matter in the paper noted above, it seems evident that officials having steam railway experience strongly favor the A. R. A. rules, and seem to find no difficulty in applying them upon electric railways. The trouble with rules alone is that so many conditions (of health, temperament, work, traffic, etc.) may easily lead to their being disregarded.

The maintenance of a space interval between trains is aimed at, by the rules. An interval of 3,000 ft. has been recommended, but some roads consider 2,000 ft. sufficient. As one writer in the discussion has naively expressed it: "If the rule of running trains 2,000 ft. apart is closely observed it is as good as 3,000 ft." Exactly, but the first word of the sentence spoils his case and under the dispatching system no one knows what is the interval between opposing or following trains. We note with interest that at least one road approaches so near to the block system as to establish certain points (about ten miles apart) as block stations. No train may pass or leave such a point without communicating with the train dispatcher, who will either give new orders or a clearance card allowing the train to proceed on its original orders. This plan is simple and inexpensive, and is efficient as far as it goes, but such block sections are too long for a desirable degree of safety. Pending the introduction of something more efficient, however, the general adoption of such a practice might well be considered by the superior officers of interurban railways.

An important consolidation of two German electrical companies is in progress, as noted elsewhere in this issue, and a further consolidation of the other two important concerns is expected. These are the latest steps in a series of consolidations, extending back for ten years, by which seven large and important concerns have been reduced to two. The situation, as it now exists in Germany, very much resembles the American situation in that two large companies handle a large proportion of the electrical manufacturing business, and where the remaining business is mostly divided between a few smaller, but still important, concerns.

The attention of American engineers has been repeatedly drawn to a supposed greater technical ability of men in the German electrical-engineering industry and to a claimed higher development of electrical engineering in that country, some of the comparisons made being not altogether complimentary to this country. Therefore it seems of particular interest at this time to note the debt which the two most powerful concerns in Germany owe to the early American inventors, and how the development of the Germany industry is based on the early American developments. The firm of Schuckert & Co., which became part of the Siemens-Schuckertwerke, allied with Siemens & Halske, was founded in 1873 by a former employee of the American Edison company. The Allgemeine Gesellschaft, the other of the two leading concerns, was founded in 1883 by the owner of the German rights for the Edison patents. This company for a time was a subsidiary of the American company. The Union Gesellschaft was organized as a branch of the Thomson-Houston Co., though it was absorbed by the ever-growing Allgemeine. A concern, bearing the name of Helios, held the German rights of the Tesla patents until the company was bought up by and distributed among the three companies leading at the time of the recent consolidation first noted. It is also worthy of note that there is a close working agreement between the General Electric Co., of Schenectady, N. Y., and the Allgemeine Gesellschaft, by which patent rights are exchanged, some of each others' engineers are trained, and harmonious trade relations in all parts of the world are adjusted.

A reliable and universally applicable solution of the problem of designing and building concrete abutments and retaining walls that will not crack would be welcomed by a multitude of engineers and contractors. There has been extensive experience with these no longer novel structures, and much also has been written upon the theories of their design and the practical features of their construction. But in spite of all this the particular problem remains unsolved, and we are inclined to think that many engineers who have to design and build these walls (and many contractors who undertake their construction) have deep-seated misgivings as to whether their completed structures will remain free from cracks. Where large amounts of concrete work of this kind are done, as in track elevation, examination will show, in many cases, cracks large in number and variety. Even in long walls with frequent expansion joints, the cracks may be in the middle of the panels or close to the joints. In fact, the aggravating part of the problem is not only the occurrence and the number of the cracks, but especially their uncertainty and their varying character. One stretch of wall may be free from cracks, while an adjacent stretch of the same wall may show numerous cracks. Some walls and abutments of this kind built by prominent railways have a very unpleasing appearance due to numerous cracks in their surfaces; yet it must be presumed that the structures were carefully designed and were built under careful supervision.

The cracks rarely indicate failure; that is to say, failure of the wall to fulfill its purpose of

retaining the earth or fill behind it. But it is very evident that they are defects which ought not to occur. Apart from this, they may arouse public suspicion as to the integrity of the work, they are very unsightly, and they tend to become still more unsightly due to the stains or sliminess from moisture weeping through the cracks. To cut out and patch the crack is costly, and the patch will usually be as conspicuous a defect in appearance as was the original crack.

Why do these cracks occur? Four causes may be suggested: (1) insufficient stability of the foundations; (2) defective design; (3) careless or improper methods in construction; (4) improper application of the load by the methods employed in depositing the fill. Elsewhere in this issue we publish an article discussing this subject, with illustrations of various typical examples. These views were selected from a large number of photographs, and the conditions are so general and so familiar that it is unnecessary to illustrate a larger number of examples. The thing is to try and discover the cause or causes, and to devise some means of eliminating these in future work. The writer of the article referred to presents his own opinions, and doubtless many of our readers have experience and opinions of their own in regard to this same problem. Of course one solution is the use of steel reinforcement, but it should be (and surely must be) possible to design and build a gravity type of unreinforced-concrete wall that will stand without cracking, bulging or tilting. The wide use of structures of this class in conspicuous positions makes it very desirable that the problem should be attacked and solved.

The engineer in general practice in Great Britain has, it seems, very little to do with the detail design of reinforced-concrete structures. This has been the general impression in this country for some time, but it is now confirmed by the cross examinations of engineers published in the "Preliminary and Interim Report of the Committee on Reinforced Concrete of the Institution of Civil Engineers," a review of which appears in our Literature Supplement this week. From that report we would gather that the general practice in England is for the engineer in charge of any work where reinforced concrete is to be used to call in one of the representatives of the numerous "systems" which hold patents there. These systems are all of a certain similarity, depending for their individuality particularly upon special designs of reinforcement on which the patent office has granted exclusive rights. Not only do the companies control these patents, but they also act as contracting engineers, both to design and to build the structure, be it wharf, building, bridge or what not. The sole duty of the engineer seems to be to check over the design as to strength and to supervise the construction in order to see that the specifications are followed.

In this country, we think, this has not gone so far. A few years ago the idea was carefully nurtured that the design of concrete was a special gift accorded only to a few who possessed the rights on special strength-giving details and who, by virtue of some experience, were alone qualified to build strongly and correctly. This idea, however, has passed away. The design of concrete, like the design of wood or steel, has been reduced, or is being reduced, to a certain standard which is based on rational methods of structural design and fundamentals of the strength of materials. Barring some advantages which are gained by the happy combination of steel in the various members, there are no basic patents which the average concrete designer is apt to infringe, if he follows out the standard methods of design. There is, therefore, no reason to-day why the average practicing engineer should not so acquaint himself with concrete design that he can prepare his drawings in exactly the same detail as he does his drawings for steel structures. In these latter, even, he does not enter into the most particular details, but leaves them to the steel contractor who, by reason of his experienced force, can make them according to the fixed standards for all steel construction. In concrete structures this same plan can be followed. The concrete contractor—a development of the past ten years—is fully competent to take care of the minor details of design, to prepare what corresponds to the shop drawings of the steel contractor.

There are in America numerous firms that are what might be called engineering contractors in concrete work, but their field is somewhat different from the concrete systems in England and on the Continent. Some of them have patents on particular designs, but as a rule they do not design for the future checking of some consulting engineer. Rather do they take the entire contract from owner or architect and make the complete designs and supervise the work. Contrary, however, to the English practice, there are few structural engineers in this country who will not now undertake to design and supervise the construction of any reinforced-concrete structure. Providing always that they have had the proper experience, this is as it should be.

Reports of typhoid outbreaks in various sections of the country are always to be expected in September and October. If such reports are more numerous than usual this year it is probably due more to an aroused interest in the subject on the part of the press and the public than to any notable excess of the disease. This aroused interest promises much for a continuation of the marked reduction in typhoid mortality during 1909, reported for the registration area by the U. S. Census Bureau.

The annual autumnal rises in the typhoid curves of most cities, as most of our readers know, are due partly to infection of food supplies by flies, partly and largely to little-understood relations between high temperature and high typhoid, and in a notable degree to the fact that thousands of people who leave the cities in summer to seek pure air, pure water and pure milk, cream and other foods, in the country really get those liquids and solids in a dirty and disease-infected condition.

Thanks to the increasing efficiency of state and local boards of health and the growing sanitary knowledge of city people the country summer resorts are becoming safer places than they were.

The notable decrease of typhoid in 1909 came largely from the cities, but there must have been notable reductions in rural sections as well, for while Philadelphia showed 188 and Pittsburg 125, less typhoid deaths in 1908 than 1909, the total decrease for the whole of Pennsylvania was 738. A considerable part of the decline in the two cities named must have been due to filtered water. Improvements in the water-supplies of other Pennsylvania cities must have played a considerable part, also, in the typhoid reduction noted, but after making due allowances for all this, sanitary progress along other lines, in both city and country, should doubtless be given no little credit for a fall of 738 deaths from typhoid in a single year.

Although cholera in Russia shows some 200,000 cases and 100,000 deaths up to Oct. 1 of this year there continues to be cause for congratulation that the disease has made very little progress further westward. True, scattering cases have been reported in other ports of Europe, Naples has had a well-merited scare, while even so far west as New York one cholera death has occurred in quarantine; but in general where modern sanitary measures prevail the cholera has either not appeared at all or only sufficiently, and that through emigration, to show how little the disease need be feared if only proper measures against it be taken.

Two results of the water famine in Westchester Co., N. Y., noted in our issue of Oct. 6, have been (1) the action of the State Water Supply Commission in directing its chief engineer to investigate the water shortages and (2) discussion of annexation of at least one municipality (Mt. Vernon) to New York City. The likely outcome of any investigation is a recommendation for a permanent supply from New York—annexation or no annexation. The apparatus of the communities involved to look [illegible] water-supply question for themselves [illegible] this is perhaps a good argument for annexation, but it ought to be feasible for any community to ensure for itself a plentiful water-supply without losing its political identity.

The Need for a More Rational View of Sewage Disposal.

Among the heavy demands now being made upon the cities of the country, few are more serious, and, perhaps, none more in need of being tempered by scientific knowledge and at the same time ordinary common sense, than those relating to reforms in sewage disposal. Fortunately, such public regulation of sewage disposal as now exists has been vested for the most part in state boards or departments of health composed of men who either understand the leading principles involved or are sensible enough to take the advice of capable sanitary engineers. The case is quite different with the few private individuals and daily newspapers who have taken it upon themselves to say not only just what ought to be done to protect the public waters of the country, but also to specify in more or less detail just how to do it.

Now and then a state health officer in some public address goes far beyond the realm of the practicable in urging that no sewage should ever be discharged into a stream or lake without previous purification. These statements, however, are to be regarded for the most part as an exposition of the ideal; and it is a notable fact that some of the state health officers who have made such statements in public addresses, or in printed pages other than their official reports, have been quite rational when called upon to approve plans for sewage disposal. There is some reason to believe that the engineering advisers of these health officers deserve a large part of the credit for the change from the ideal to the practicable which takes place when some of the state officials turn from the framing of a general address to the formulation of a report on a specific sewage disposal plan. Inasmuch as these general addresses by state health officials have, or should have, much to do with the formation of public opinion on questions of sewage disposal and stream pollution, it is highly desirable that the public addresses of these men should be made to conform more closely to their official action.

Without intending any reflection whatever upon the ability, judgment and devotedness of the members of state boards and departments of health, we may say that for the most part they are dominated too much by men of medical training and of little knowledge or experience in either the theory or practice of sanitary science. A few states have had the wisdom to include one engineer in the membership of their state boards of health, but we recall only one such board which has as many as two engineer members, while engineers are not represented at all on most of the state boards of health of the country. Without exception, the executive health officer in the various states is a man of medical rather than engineering training, and, as most of our readers understand, it is the executive health officer as a rule who decides a large proportion of the vital questions which come before our state boards of health.

The more efficient state boards and departments of health throughout the country have well-manned engineering, chemical and bacterial divisions, each with one or more men well grounded in the principles of sanitary science. The opinions of these men generally have great weight with both the executive health officers and the membership of the boards or departments. It appears to have been the lack of technical advisers of any kind that led one of our state boards of health some years ago to issue a blanket order requiring every municipality in the state possessed of a sewerage system to install septic tanks. This was in the early day of the septic tank when there was more of a glamour cast about it than at present; but it serves well to

illustrate how far state health boards dominated by medical men and not guided by the advice of engineers are liable to go astray.

The relation between sewage disposal and water pollution, the reasonable demands which may be made on behalf of keeping any stream free, or relatively free, from pollution, and the principles and methods of sewage treatment are now so well understood that there is no longer any excuse for other than a rational attitude toward all sewage disposal questions on the part of any and every state board of health in the country. Notwithstanding anything that might be inferred from the foregoing remarks, we are decidedly of the opinion that for the most part our state boards of health have taken a fairly rational view of sewage disposal for some time past and give promise of doing even better in the future. At the same time, we think it can do them no harm, and may do our municipalities and the general public much good, if the need for a rational view of sewage disposal is continually brought to the front until the principles involved are better understood by the general public than they are at present.

The change from general apathy and indifference to a demand for radical, and often wholly unreasonable, action which accompanies the initiation of nearly all reforms is beset with particular dangers. As regards sewage disposal, the public, or at least a considerable portion of it, having suddenly come to a realization of the fact that serious nuisances and also grave dangers are liable to follow the unregulated discharge of sewage into public waters, immediately jumps to the conclusion that all such discharge ought to be stopped forthwith. The wildest and most unreasoning advocates of radical changes will at once begin to talk of sewage disposal by cremation; but this is more generally due to confusion with garbage disposal than to any real idea that sewage can be burned. What is commonly advocated with the utmost sincerity is that sewage should be so purified before its discharge into water that it will have no effect upon the purity of the stream or lake which receives it. How impracticable this is, these advocates never dream. Most of these uninformed advocates of extreme measures in sewage purification have heard wonderful stories about the great profits derived from sewage farming abroad. With no knowledge whatever of the actual practice in Europe or the practicability of adapting foreign methods to the very different conditions which prevail in this country, these enthusiasts urge our municipalities to purify the streams and at the same time to pile the coin into the municipal treasury by entering upon sewage farming.

One thing which the general public needs knowledge of more than almost anything else in order that it may have a rational view of sewage disposal is that sewage treatment on land may cause a nuisance as well as sewage disposal into water and that in any event the effluent from land treatment must inevitably find its way sooner or later into some body of water. How much or how little of the impurities in sewage can be removed by land treatment is a point upon which the general public is sadly in need of information. The facts are, as we hardly need state to a large part of our readers, that the systems of sewage treatment now most in vogue cannot be relied upon to effect any certain and high degree of bacterial purification. All that is really aimed at, as a rule, is to render the sewage non-putrefactive. Oftentimes, sewage can be brought to a non-putrefactive stage quite as readily, or even more readily, by discharge into water than by first discharging it upon land. It is therefore absurd to insist, as so many of the would-be conservators of public waters do, that sewage must always be purified before it is sent into the water which must ultimately receive it. In fact, sewage purification is a merely relative term and can never be safely used without qualification.

There is another side to this question on which we have often touched, but which it is necessary to mention again and again. We refer to the fact that sewage-purification works are but one of the multitude of things which any given municipality at any moment may need to build, either for the protection of its own citizens or those of other communities. There is, unfortunately, a rather hard and fast limit upon the expense which any city can incur within a given period of years, and on this account demands for sewage purification should always be considered in the light of their relative importance as compared with other expenditures for the health and comfort of the city in question. It may, of course, be said that no city has a right to so dispose of its own wastes as to endanger the lives of the people of any other community. Broadly speaking, this is indisputable, but as a practical matter no city to-day can reasonably be called upon to turn its sewage into drinking water, and that is the only way by which absolute protection of other communities could be insured in case the sewage in question involved public water-supplies.

So far as safe drinking water is concerned, the question is one of water purification, rather than sewage purification. It may be that some of our cities will yet be called upon to contribute toward the expense of water purification for cities whose water-supply is threatened, but we have not yet come to that point.

As a matter of fact, most of the sewage-disposal problems of the day can scarcely be said to involve public water-supplies, even though they do involve more or less danger to such supplies. As we have already stated, the sewage-disposal problem is chiefly one of offense through putrefaction. It is high time that this was more fully recognized by some of our state boards of health.

Our reason for recurring again to some of the points covered in earlier editorial discussions, prompted by the recent Rochester sewage-disposal case and by successful defeats of efforts to secure more stringent control over anti-sewage-purification methods in New York State (see Eng. News, June 9, p. 677; Sept. 15, p. 284), is the fact that we are publishing elsewhere in this issue an article entitled, "First-Hand Impressions of German Sewage-Disposal Works," by Prof. H. N. Ogden, of Cornell University, and a letter from Prof. Palmer C. Ricketts, Rensselaer Polytechnic Institute, suggested by our recent discussion of the defeated New York legislation. It is quite unnecessary to even summarize the article and the letter in question, further than to state that Professor Ogden brings out with considerable emphasis the rational views and practices of the Germans in matters of sewage disposal, and that Professor Ricketts shows with equal emphasis how the earlier attitude of the New York State Department of Health toward the city of Troy threatened to make all their municipal work in that city quite subordinate to the purification of sewage which was to be discharged into the already seriously polluted Hudson. We may add that Professor Ogden shows that while German and American stream conditions as regards sewage-disposal capacity are quite similar to our own, yet the Germans aim only at a slight degree of purification, designed merely to prevent putrefactive nuisances, while the tendency of some of our American state boards of health has been to demand a high degree of purification. We may also direct attention to Professor Ricketts' interesting remarks on vesting, or attempting to vest, more or less absolute power over sewage disposal in New York and Pennsylvania in a single-headed commission as compared with lodging the same power in the State Board of Health of eight members in Ohio, and at the same time giving the municipalities of the last-named state power to appeal to a board of three sanitary engineers whenever in the judgment of the municipalities the rulings of the board were unreasonable.

A word of comment may be passed on the reference by Professor Ogden and Professor Ricketts to manufacturing wastes in their relation to stream pollution. One reason, we suppose, why our state boards of health have been so much more stringent in their dealings with domestic sewage and municipalities than with manufacturers and their trade wastes is that it has been possible thus far to secure legislative warrant for dealing with city sewage and has not been possible to get all needed authority for bringing manufacturers within control.

More rapid progress in bringing about the adoption of a rational view of sewage disposal on the part of the general public would be made if only the daily press of our cities would take up the subject with more approach to that degree of reasonable intelligence which might be expected; at least, some of them might take more pains to secure actual facts pertaining to the city under discussion even if they were excused from possessing themselves of and expressing accurate opinions on scientific matters. By far the worst sinner in this respect, particularly if one takes into consideration the fact that for many years the journal in question was one of the very few dailies in the United States to employ a technical editor, is the "New York Times." Of all the ill-informed and unscientific utterances to which it has given vent during the past two or three years its latest comments on the Rochester sewage-disposal case take the lead. We resisted for some weeks a strong temptation to publish and comment on the following gem from the paper named. We now give it, title and all, as follows:

WE BLUSH FOR ROCHESTER.

When Rochester had defiled the Genesee River so that the nuisance was unendurable, what was the next thing to do? The idea of stopping defilement never occurs to anybody except under compulsion of law, so long as there is an easier and cheaper alternative. In Rochester's case Lake Ontario lay near at hand, and the obvious thing was to defile that. The consideration that some people must drink that water was nothing to Rochester, and it prepared to go ahead. As mere matter of form it submitted plans for the purpose to the State Commission of Health, who held a public meeting on the subject and took the advice of engineers. Both public and technical opinion was adverse, and the plans have been returned to Rochester with the advice to make suitable provision for the purification of its sewage.

This simple story seems to call for some expression of indignation and shame by somebody, and, since Rochester seems incapable of it, we blush for Rochester. Our hope is that the sight of Rochester in the pillory may discourage any similar plans under contemplation any nearer New York than Rochester. In Rochester's case it is evident that if it is to purify its sewage before emptying it into Lake Ontario it might as well purify it before emptying it into the Genesee River.

From start to finish there is hardly an unqualifiedly true statement in the foregoing quotation, unless it be the title, and as we have never yet seen a daily newspaper blush we are strongly inclined to question that. The first motion to stop the pollution of the Genesee river was made long ago by the City of Rochester itself. In the plans finally submitted to the State Commissioner of Health, most careful consideration was given to the possible relation of the discharge of sewage into Lake Ontario to the water-supply of the comparatively few people who could be in any way affected by the proposed sewage-disposal works. The plans were submitted to the State Commissioner of Health, not as a matter of form, but because the city could not have done otherwise had it been so disposed and because it had no disposition to do otherwise if it could. There was practically no public opposition at the hearing given by the Commissioner and the technical advice of the eminent engineers called in by the State Commissioner of Health not only supported the plans in practically all their essential details but the plans were also supported in like manner by the Chief Engineer of the State Department of Health. In returning the plans to Rochester only slight changes were suggested (as we stated in some detail in our issue of Aug. 11, 1910, p. 154). The city is not called upon under the amended plans to do more than give a slight screening and a relatively small amount of sedimentation to the sewage. The screening is less than was provided by the original plans and the sedimentation, though double in point of time, is yet small in effect. The principle and practice of sewage disposal by dilution remain not only unchallenged by the Rochester case but they are supported as never before by a half-dozen of the best sanitary engineers of the country.

Gross as are the errors in the editorial which we have quoted, we call attention to them more to emphasize the general points which we have been endeavoring to make through our whole discussion than to bring condemnation upon either

the public press as a whole or any individual member of it. At the same time, and as we have already stated, it is a pity that instruments which are supposed to have so much effect in shaping public opinion of the day as the daily newspapers of the country will not take more pains to see that they are not "blind leaders of the blind." We do not think the public has really been led to fall into a pit in this particular case, but, clearly, the would-be leader has fallen into a pit of its own digging. We suggest that on future occasions it save its blushes for itself.

LETTERS TO THE EDITOR.

A Steep Grade on the Underside.

Sir: I enclose a newspaper statement of great interest to engineers:

CALIFORNIA SPRINTER RUNS 100 YARDS DOWNHILL IN 8⅘ SECONDS.—Waldo Throop, a nineteen-year-old student of the University of Southern California, broke all records a few days ago by traveling 100 yards by his own efforts in 0.08⅘. Throop's remarkable run was made on an ordinary street, but down a grade of 512 degrees. The sprint was made at the suggestion of Coach Cromwell, who believes it will introduce a new branch of track sport. Throop is one of the best men on the coast in a 100-yard sprint, having an official record of 0.09⅘.

I think there are few of us even in our athletic days who have ever run down a grade of 512°, and as this is a record-breaking grade, it easily accounts for a record-breaking run.

H. S. Wood.

Park Row Bldg., New York City, Oct. 4, 1910.

The Flow of Water in the Colorado River.

Sir: Please state that I have had no connection whatever with making any recent "compilation" or summary of data in regard to the flow of the Colorado River at Austin, Texas. I want all parties not to credit any report ascribed to me that is not signed by me. The only summary that I made was for the years 1896-97-98-99, published in Water Supply Paper 105 of the United States Geological Survey. The figures in the summary referred to the flow from the lake and not the flow *into* the lake. In other words they represent facts in regard to the flow from a partially impounding reservoir and not the free flow of the river. The summary referred to does not apply to the last ten years.

Respectfully, T. U. Taylor,

Professor of Civil Engineering, University of Texas.

Austin, Tex., Oct. 1, 1910.

"Water Rates" and "Hydrant Rentals."

Sir: In the excellent editorial upon Water-Works Questions, in your issue of Sept. 29, the following sentences occur:

Looking at the subject from quite another point of view, the aim of any city would be to see that an ample supply of pure water, sufficient also in quantity for fire protection and industrial purposes, was available to any and every citizen within the municipal limits, so far as this was not rendered absolutely impracticable by a very scattered population. Obviously, water-works under private ownership cannot accept such a doctrine unless the water rates are high enough to make a profit on well patronized lines of mains sufficient to carry the fixed charges and operating expenses on lines serving only one or two consumers. Such a policy has elements of injustice and is not likely to be permitted where the water consumers are aware that it is being followed.

The phrase "water rates" is sometimes used to cover the entire receipts from water supplied to a city whether by municipal or private works. But when so used it should be remembered that with few, if any, exceptions in company plants the "water rates" comprise the sums paid by individual consumers for water and by the city for fire protection. This fire protection item is often called hydrant rental and is raised by a general tax in all respects similar to a municipal tax for any public service. And it is from the hydrant rental so provided for and paid that funds are derived to make extensions in both crowded and sparsely built up streets. Where thirsty individuals gather in this latitude it is reasonable to expect there will be property requiring fire protection which private companies furnish without maintaining unlike schedules of rates for different streets in the same city. Urban residents cannot be indifferent to the welfare of an isolated manufacturing plant or a new addition within the corporate limits and it seems just that they should, under well recognized ordinances, aid in maintaining fire protection and a domestic supply in outlying districts.

Yours truly,

H. F. Dunham.

220 Broadway, New York City, Oct. 1, 1910.

Some of the Reasons Why Stream-Pollution Legislation in New York State Has Been Defeated.

Sir: I have read with interest the editorial in your issue of Sept. 15, entitled "The Continued Legislative Defeat of More Stringent Control over Sewage Disposal in New York State." In referring to the recent defeat of bills in the New York State Legislature dealing with this subject you very pertinently observe that

the continued defeat of this legislation will doubtless have a sobering effect upon both the State Department of Health and some of the unofficial would-be conservators of the purity of the waters of the state. The continued defeat indicates that all concerned in the prevention of stream pollution must have a care lest they attempt to go faster than public opinion warrants. Water pollution may undoubtedly be a serious nuisance and a possible grave menace to public health. At the same time, it is far easier to declare that it must be stopped than it is to provide ways and means of stopping it without injury to some industries, or without crippling municipal activities in directions which are perhaps far more important to the public convenience and health than are the improved means of sewage disposal. . . . . We suspect that the strongest and most effective opposition to this legislation came from the manufacturing interests, and particularly those behind the paper and pulp industries, although there is little question but that strong opposition may have come from some of the municipalities of the state.

I know nothing whatever about the opposition of any manufacturing interests to the bills introduced, but I do know that some of the opposition was due to some of the municipalities of the state which had cause to fear unreasonable application of the power given in these bills to the State Department of Health. When in 1905 application was made to the State Department of Health by the City of Troy for permission to extend certain existing sewers, it was informed, in a letter dated Nov. 28, 1905, that

it is the present policy of this department to secure, in situations which render them desirable and feasible, the accomplishment of two results: First—The stopping of the increase of population without immediate reference to the elimination of existing pollution, excepting in places where the latter becomes essential and justifiable.

The city was further informed that it could not extend its sewers without agreeing to provide a system of sewerage which would keep the sewage proper separate and distinct from the surface water, as well as disposal works "for the purpose of purifying sewage" before Jan. 1, 1909. I call particular attention to the statement regarding "the stopping of the increase of population."

Having been, some years ago, Engineer of the Public Improvements Commission of the city of Troy, at which time I had to design sewers for a large part of the city and construct some miles of new sewers, I was familiar with existing conditions when the bills giving the Commissioner of Health power to enforce these requirements came before the Legislature. Space here will permit only slight reference to the difficulty and expense of constructing the plant required. Troy has the combined system. A new separate system for sewage only would mean, in most streets, the construction of two entirely new sewers, one on each side of the existing sewer, with house laterals generally about 25 ft. apart. This would involve the tearing up of sidewalks and pavements, and complex crossings of the new sewers with the old ones and with underground pipes, together with sidewalk vault and other complications. The city is thickly built up along the Hudson River for a distance of about eight miles, and the case is further complicated at times by 15 or 20-ft. floods which back water in the sewers, overflowing some of the streets nearly half a mile from the river, and by the two large streams flowing through part of the city to the river. Evidently this is not a case for edicts but for careful consideration by sewerage engineers of the highest class. The expense would far exceed the city's constitutional debt limit and would be almost impossible to be borne. If the city could have been forced to build the plant and had paid for it by direct taxation, the already high taxes would have been more than doubled, many property owners would have been forced to give up their holdings and public improvements would have been stopped for years. Is it wonderful that there should be opposition to these bills? Is the city of Buffalo, for instance, which discharges nearly all of its sewage into the Niagara River, with its great volume at a point where its velocity is from 5 to 10 ft. per sec., to be compelled to construct a separate system of sewers, treat its sewage and in consequence stop other needed public improvements for years in order that a small town on the river below it may not have to filter its water? Is the city of Albany to be unwillingly compelled to do the same with the same result? Some years ago a commission appointed by that city showed it to be perfectly feasible to bring an adequate, good water supply at a reasonable cost across the Hudson from a stream on the east side. It preferred to take part of its water-supply from the Hudson and filter it, with the result that it has a safe and satisfactory supply. So much so that an eminent physician of that city described its purity in glowing terms at a hearing on one of the bills in question before a legislative committee.

Lately the Rochester case has come to the front. [illegible] opinions of not only the very able engineers of [illegible] and state boards of health, but of such eminent consulting engineers as Benzenberg, Hazen, [illegible] ing and Kuichling have been recognized. The [illegible] of that city is to be discharged, after sedimentation and screening, in tanks aggregating in volume [illegible] of one about 100 × 100 × 10 ft., *but without treatment* into Lake Ontario. In spite of repetition, since [illegible] printed in your issue of Aug. 11, and on account of great practical value and its probable future [illegible] in the consideration of these cases, I quote a short extract from the report of Allen Hazen:

In my judgment the plan submitted is sufficient [illegible] neither of the two auxiliary procedures mentioned [illegible] be resorted to. The disinfection of sewage no [illegible] has its uses, but it is a somewhat difficult and [illegible] mental process at the present time. If it were [illegible] out in this case its only use, so far as I can [illegible] would be to tend to protect the water taken [illegible] Rochester & Lake Ontario Water Co. from pol[illegible] This water I understand is filtered before use. T[illegible] infect the Rochester sewage with this end in view [illegible] mean (1) treating a quantity of sewage probably [illegible] times as great as the volume of water, and (2) treating sewage which is a difficult and expensive substance to disinfect, instead of treating the lake water taken [illegible] filter plant, which is an ideally easy and cheap substance to disinfect. It would certainly cost ten times as much to disinfect a volume of sewage as a volume of water at the intake, and with the greater volume of sewage it would cost at least one hundred times as much to disinfect the Rochester sewage as it would to disinfect the water taken at the intake. The [illegible] would only protect the water from that part of the possible pollution which came from the dry-weather flow of the Rochester sewage, which is probably not the most dangerous part of the flow. The latter would fail to protect the water from pollutions of all kinds from whatever sources.

From every standpoint it is enormously cheaper and also more effective to treat the water than it is to try to protect the water by treating the sewage.

To treat the sewage by oxidation or nitrification through biological filtration on the shore of the lake before discharging it would be to attempt to effect by artificial processes, at great expense, results that will be accomplished in the lake without cost by the organisms that are in the lake water and that are introduced with the sewage with the aid of the supply of dissolved oxygen in the lake water present in amounts enormously greater than required for this purpose. To spend money to do in a crude and inefficient way on shore with resulting inconveniences and nuisances to property owners in the neighborhood that which otherwise will be freely done in the lake without expense and without nuisance is certainly a great and inexcusable waste of natural resources.

To return to legislative acts affecting this question. As far as my knowledge goes, all that the municipalities of the state want is a *legal assurance* that their cases will be fairly considered by a body of men fully qualified to judge them from accurate knowledge of the principles involved. But I believe they desire this *legal assurance*. In your editorial you refer to the laws of Pennsylvania and Ohio. The laws of Ohio provide for this assurance. Section 4 of the law relating to the protection of water-supplies reads as follows:

IN CASE OF DISAGREEMENT MAY SUBMIT QUESTION TO SANITARY ENGINEERS; POWERS OF REFEREES; EXPENSES AND FEES; HOW PAID. If in any case any order of the State Board of Health, when approved by the Governor and Attorney General, and made in pursuance to the provisions of this act, is not acceptable to any city, village, corporation or owner affected thereby, such city, village, corporation or owner shall have the right of appeal as follows, to wit.: The necessity for and reasonableness of such order may be submitted to two reputable and experienced sanitary engineers, one to be chosen by the city, village corporation or owner to which such order of the State Board of Health applies and the other chosen by the State Board of Health, who shall not be regularly employed by said board, and who shall act as referee engineers. If the engineers so chosen are unable to agree then they shall choose a third engineer of like standing, and the vote of the majority shall be final and binding. The referee engineers, herein provided for, shall have power to affirm, modify, or reject, the order of the State Board of Health submitted to them, and their decision, as reported in writing to the Governor and Attorney General, which shall be rendered within a reasonable time, shall be accepted by the State Board of Health, and shall be enforced by said board in the manner provided for in this act. The fees and expenses of said referee engineers shall be equally divided between the city, village, corporation or owner requesting such reference and the State Board of Health.

It will be noted that the cities in Ohio have the right of appeal to engineers even when the order of the State Board, which incidentally is composed of eight members, is approved by the Governor and Attorney General. As a matter of fact, the approval of these two officers must in general be perfunctory on account of the multiplicity of their duties and their probable want of technical knowledge of the cases brought before them. In the bills rejected by the New York Legislature a restraining order of the State Commissioner of Health was not to be valid until approved by the Governor and Attorney General, but no provision was made for a hearing before either of these two officials, nor was there at most any provision for even a court review, and it was not until great opposition had developed that the following clause was added to the last bill introduced:

Nothing in this chapter contained shall preclude the review of any action or determination of the Commissioner of Health or of any officer charged with the enforcement of this chapter in any action, proceeding or prosecution which shall be instituted under it.

The laws of Pennsylvania afford to municipalities no

such appeal as the laws of Ohio. The bills recently rejected by the Legislature of New York were practically the same as those of Pennsylvania. In both cases the board is composed of one man. I will cite the case of Philadelphia. It

is required to *treat* its sewage and with that end in view it is under obligation to prepare and submit to the State Department of Health before the year 1912 for approval a comprehensive plan for the collection and disposal of the sewage of the city.

In the light of present competent engineering opinion it must be assumed that before Philadelphia is put to the very great expense of collecting and treating that part of its sewage now being discharged into the Delaware River the plans will have the approval of a number of the most expert of sanitary engineers.

Advocates of sewage treatment for all cities and towns on all rivers, regardless of the volume of discharge, often make the erroneous assumption that such treatment will insure the purity of the water in the rivers. This, of course, is far from being the case. A large river in a thickly populated district is a sewer. The storm-water discharge from the streets of cities on its banks cannot be effectively treated. Storm-water overflows from combined systems carry a part of the house sewage into the river. They palliate but do not prevent pollution. The water is unfit for drinking purposes unless it be filtered. The Hudson River at Troy, with the surface drainage of more than two hundred cities, towns and villages on the banks of it and its tributaries above Troy in New York State and other states, is a sewer. No sewage treatment will make it other than a sewer. Its water cannot be used for drinking purposes without being filtered and its great volume, even in times of minimum flow, renders it inoffensive for other purposes. Its water can be and is made safe for drinking purposes when filtered. Why crush cities upon its banks with existing combined systems by compelling them to go to the almost unbearable expense of providing a separate system also?

The question is a relative one. When sewage makes a stream offensive it should be treated. But in considering the question of sewage discharge in its relation to water-supply many laymen, through want of knowledge of the engineering difficulties and true sanitary principles involved, put, I believe, the cart before the horse. In my opinion the true position to take, not only from a sanitary standpoint but from the standpoint of a clean water-supply for general domestic use, is that with very few exceptions *all* municipal water supplies should be filtered. I believe that when people generally come to appreciate the fact that filtering insures water which is not only practically safe but *clean* throughout the year they will be willing to pay the increased cost involved in the installation of a filter plant. I believe that this view is held by most of the best sanitary engineers in this country. It certainly is held by eminent engineers abroad.

In a paragraph I have quoted from your editorial you refer to "unofficial would-be conservators of the purity of the waters of the state." The moderation and scientific accuracy of your editorial methods are in strong contrast to the action of the management of a New York City daily newspaper which, in an inspired editorial dealing with the subject matter of this communication, recently published a scurrilous criticism of an individual coupled with entirely false and libelous statements regarding a municipality of this state and refused to publish a moderate answer to its criticism of the individual and its libel on the city. The individual leaves his opinions on this subject to the consideration of engineers, with the knowledge that those most capable of judging hold substantially the same opinions. As far as the municipality in question is concerned, two statements are true: (1) That Troy never refused to harbor a tuberculosis exhibit. On the contrary, it had one. Furthermore, it was one of the few cities of the state and one of the first—either the first or the second, I believe, since the crusade against tuberculosis was started—to build a hospital for tuberculosis patients. The county built it but the movement for its construction was inaugurated in Troy and a large part of the expense was borne by the city. (2) It is to-day, and has been for several years, one of the most thoroughly cleaned and probably the most thoroughly cleaned of the cities of the state. The last paragraph is pertinent in this connection for the reason that it calls attention to the fact that while a city may be willing to spend large sums for proper sanitary reasons, it has the right to object to being forced into the expenditure of comparatively enormous sums for sanitary engineering purposes until such expenditure is sanctioned by the best sanitary engineering experts. And it is further pertinent because it calls attention to the methods of some of the would-be so-called conservators of the purity of the water-supplies of this state who have attempted to force municipalities, by the use of ignorant popular clamor, to be subjected without reasonable chance of appeal to authority which in the past has attempted to enforce unreasonable and arbitrary orders. Such unreasonable orders would of course be resisted in the courts, but the state, in enacting laws, should provide safeguards rendering long and expensive litigation unnecessary. Such proper safeguards, which the laws of Ohio provide, would, I believe, remove much opposition to the bills in question.

One thing should be appreciated by the advocates of these bills. They must be fair and must afford reasonable protection to all concerned before they will be passed. Fictitious popular sentiment will not pass them. False statements, dragooning or threats will not. The interests at stake are too great. Enlightened opinion will continue to demand that a proper sense of proportion be used in the enforcement of sanitary acts. The victims of typhoid fever are to be remembered, but those of tuberculosis, numbering many times those of typhoid fever, are not to be forgotten. All reasonable attempts must be made to stamp out typhoid fever. Not only those cases due to the water-borne germs of large rivers, but *the very much larger number of cases not chargeable to this cause.* But reason should be used in these attempts and I am sure that the cities of this state are anxious to proceed as far as they possibly can in this direction (to again quote the words of your editorial) "without crippling municipal activities in directions which are perhaps far more important to the public convenience and health than are the improved means of sewage disposal.

Yours very truly,

Palmer C. Ricketts.

Rensselaer Polytechnic Institute, Troy, N. Y., Oct. 1, 1910.

Notes and Queries.

In connection with Prof. C. A. Holden's mention of a duplicate page note-book for surveyors (Eng. News, Sept. 29, 1910, p. 339), Kolesch & Co., of New York, inform us that there is on the market a "Duplicating Field Book" which is an ordinarily bound field book, except that every other page is perforated and punched so that the pages can be torn out without destroying the binding.

The Committee on Exterior Treatment of Concrete Surfaces of the National Association of Cement Users, whose preliminary report was printed in Engineering News, Sept. 15, 1910, p. 291, wishes to obtain additional information from manufacturers, engineers and users of appliances for coating concrete surfaces, the information to be used in the preparation of the final report of the Committee. Any correspondence on this matter should be addressed to the Chairman of the Committee, Mr. Leonard C. Wason, 8 Beacon St., Boston, Mass.

Rebuilding a Double-Leaf Bascule Bridge as a Single-Leaf Bascule.

The reconstruction of the eight-track railway bascule bridge over the Chicago Drainage Canal at Campbell Ave., Chicago, is an interesting example of modern developments in bridge design. The work is described in a paper by Mr. C. R. Dart and Mr. S. T. Smetters (Bridge Engineer and Assistant Engineer of the Chicago Sanitary District) which appears in the August number of the "Journal" of the Western Society of Engineers. From this paper the following particulars are taken. It should be explained that this is not really an eight-track bascule, as the movable part of the bridge consists of four independent (though parallel and adjacent) double-track bascule spans. Two of these are used by the Pennsylvania Lines and one each by the Chicago Terminal Transfer Ry. and the Chicago Junction Ry. An eight-track swing span was originally designed, but was not approved by the railways. Competitive designs were called for, and that of the Scherzer Rolling Lift Bridge Co. was accepted. This bridge was completed in 1900, and was described and illustrated in our issue of May 22, 1900.

This original design provided for four adjacent double-leaf bascule spans of 150 ft. between bearings, and two riveted deck truss flanking spans of 100 ft. The bridge was never operated, but was in service for nearly ten years as a fixed bridge. At the time of its construction the drawbridges over the canal were not required to be operated, and the machinery was omitted in order to reduce the first cost. In this structure, therefore, the segmental heel girders, the track girders (on which the heel girders roll), the counterweights and all operating machinery were omitted. It had, in fact, a fixed channel span which was a three-hinged arch (with horizontal top chord), having one pin at the intersection of each lower chord and end post (vertical), and one in the center of the upper chord. It had through-trusses, with the bottom chords inclined downward in the end panels.

In 1907, under a law requiring the bridges to be made operative, plans were prepared for completing the movable leaves and equipping them with the necessary machinery. An estimate of the cost of this work, however, showed that new single-leaf channel spans could be built at a comparatively small increase in expenditure. These would act as simple spans when closed, and would be much simpler in operation. Furthermore, the original bridge was already ten years old, and had been designed for a lower live load and higher unit stresses than are used in more modern practice:

The double-leaf spans required two sets of machinery, four segmental girders, four track-girders, four anchorages for each span, and an expensive center-lock in each truss to insure that the leaves would engage properly when closing. With single leaves, the number of segmental-girders, track-girders and sets of machinery could be reduced 50%, and all anchorage and center-locks dispensed with. There is no doubt that single leaves are preferable to double leaves for railway bridges and would be most satisfactory to all parties concerned.

Bids were received for altering the existing double-leaf spans and for building new single-leaf spans. The latter plan was adopted, and the contract was let in 1908 to the Chicago Bridge & Iron Works.

The new bridge (or, rather, the new movable part of the bridge), consists of four Scherzer rolling-lift, single-leaf, through-truss double-track spans, 164 ft. c. to c. of bearings. Alternate leaves roll back on opposite sides of the channel in opening. The close spacing of the separate adjacent spans made this necessary, as there was not room to apply the operating racks and machinery between adjacent leaves on the same pier. The approximate weight of each leaf is 1,738 tons, distributed as follows: structural steel, 702 tons; machinery and electrical equipment, 38; counterweight (940 for concrete and 10 for pig iron), 950 tons; floor and track, 48 tons.

The adoption of the new design necessitated a change in the substructure, as the channel piers were not wide enough to carry track girders of sufficient length for the longer travel of the single-leaf spans. Four 9-ft. cylinder piers were sunk behind each main pier to carry the shore ends of the longer track girders. These were sunk by the pneumatic process and were carried to bed rock at 35 to 45 ft. below datum. This was required at both piers for the reason that alternate spans had their rolling heels on opposite sides of the channel, as noted above. This work was completed early in 1909.

For the removal of the superstructure, one double-track span was abandoned at a time, and all traffic carried by the other spans. When this first old span had been removed and the new one erected, traffic was diverted upon it and another parallel old span abandoned for reconstruction. As the channel had to be left unobstructed, falsework could not be used. The old double-leaf span to be removed was first converted into two cantilevers by anchoring the top of each end post to an old floor beam placed in the trusses of the approach span. The anchor chains were composed of old eye-bars, and take-up bolts at the anchorages enabled the chains to be tightened so as to relieve the load on the center pier of the span. The new single-leaf span was built in the closed or lowered position, the segmental rolling girder being blocked in position and concrete being placed in the counterweight box as the work on the truss progressed so as to maintain a slight excess of counterweight. As a precaution, however, the rear end of the leaf was anchored to the track girders by cables, which were passed over the counterweights.

Each leaf has two 50-HP. motors for the operating racks, and is provided also with hand-operating gear. The signalman in the interlocking tower south of the bridge has control of current for the motors by means of a cut-out in the bridge operator's cabin.

The first of the old double-leaf spans was abandoned on July 12, and the new span was put in operation on Oct. 2, 1909, the entire work having been done in 82 days. The work on the second span was done between Sept. 15 and Nov. 22, 1909, or in 68 days. The four spans were all completed by May, 1910.

Siphon Spillway on the Champlain Canal.*

At three localities on the Champlain division of the Barge canal there are being built structures of a new type—intended to fill the office of spillway or waste-weir, and designed by Mr. George F. Stickney, Supervising Engineer. Two of these will discharge from the canal and into an adjacent stream the surplus waters that accumulate from an intercepted drainage area.

As a widely fluctuating canal water-surface is to be avoided, if possible, it is necessary to get rid of any surplus, and if this water may at times flow in rapidly, it must be discharged with equal rapidity. Ordinarily this has been accomplished by a waste-weir with sufficient length of spillway to pass the required amount in the given time. However, when the volume is large, the spillway must be long, and sometimes conditions exist which make a long spillway undesirable or even impossible. The presence of such conditions, especially in the case of one of these three structures—the one at Whitehall—has led to the designing and introduction of this new structure, a type which will perform the same amount of work as an ordinary spillway, but with a decided reduction in length, the ratio varying from one to three to one to five at these particular spillways, depending, of course, on the available head of water, while at the same time the economy in cost of construction is considerable.

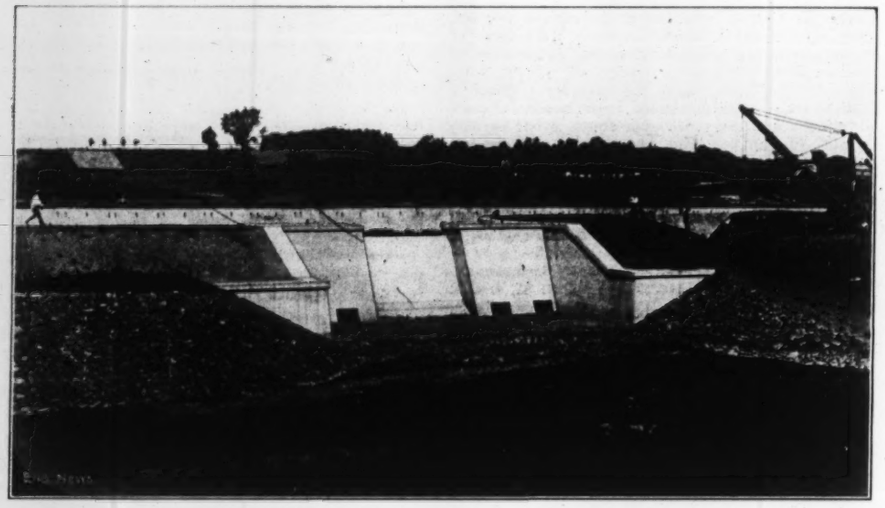

FIG. 1. VIEW OF SIPHON SPILLWAY AT SMITHS BASIN, LOCK NO. 9. CHAMPLAIN CANAL.
(Looking toward canal; lower end of siphons shown.)

These structures have been designated "siphon spillways." It is believed that in them the siphon principle is used for the first time to create a spillway of any considerable size. The siphon action will be entirely automatic, in both the starting and stopping of the flow.

As previously stated, there are three of these siphon spillways planned for the Champlain canal. These differ in size and in the number of siphons employed. One of the spillways is at Whitehall, another at Fort Edward and a third at Lock No. 9, which is near the hamlet of Smiths Basin.

The Spillway at Lock No. 9 is completed (Fig. 2). It is situated on the summit level of the canal, and this level receives the drainage from a small area of adjacent land, the maximum inflow amounting to some 700 cu. ft. per sec. in times of heavy rainfall. It was desired to provide for this volume of flow and also to limit the fluctuation of water-surface to about one foot. The ordinary waste-weir of a capacity sufficient to take care of this flow, with a depth of only 1 ft. of water on the crest, would require a spillway 200 ft. long. The siphon spillway, however, measures but 57 ft. between abutments, and it accomplishes the same result. The structure (Fig. 1) consists of four siphons and a waste-weir 20 ft. long, the purpose of the weir section being to serve as a gap to carry off floating debris. Each of the siphons has an area of 7¾ sq. ft. Acting under a head of 10½ ft., each one will discharge approximately 160 cu. ft. per sec.; while the waste-weir, with a depth of 1 ft. of water on the crest, will have a discharge of 70 cu. ft. per sec., the total discharge for the whole structure thus being about 710 cu. ft. per sec. The inlet of the siphon is placed well below the water-surface and is protected by a screen to prevent the entrance of floating bodies that might happen to drift into the pipe and lodge in one of the several bends of the siphon. In order to reduce the loss of head due to entry, the inlet is flared out to double the normal area. As the siphon will not come into action until completely filled with water, it was necessary to limit the height at the crown to 1 ft., but the necessary area was obtained at this point by increasing the width. From the crown to the outlet the siphon is practically uniform in area, though the dimensions were changed from 1 × 7¾ ft. to 2 × 4 ft., in order to give a better section to the masonry and also to facilitate the removal of forms used in construction. At the crown, where the removal of forms would have been difficult, iron castings were provided, which were left in the masonry. Three vents, each 6 ins. high × 12 ins. long, pierce the wall at low-water level above the inlet of each siphon. When the water has been drawn down to this level, air will enter through these vents and stop the flow through the siphon. A little below these vents a single opening of the same size acts as a precautionary vent to break the flow in case the upper openings become clogged in any way—by freezing or otherwise.

The siphon spillway at Whitehall is being built in the channel of Wood creek. Here the problem was to pass the flood waters of the stream within an exceedingly limited space. Because of existing power plants, a dam had to be maintained in the creek at the side of the new canal lock. The canal and the stream are both confined to a narrow gorge, the side next to the creek rising almost precipitously, simply allowing space for the buildings which reach to the water's edge. The new lock occupies the same location as the old lock, but its greater width so contracts the creek channel that some rapidly discharging device is absolutely necessary. The structure containing the siphons will serve as a part of the dam across the stream. The automatic feature of the siphon, dispensing with attendance, is especially favorable. The structure will have a capacity about equal to the one at Smiths Basin. There will be six siphons, each of which, operating under a 16-ft. head, will discharge 110 cu. ft. per sec. In order that the siphons may make the least possible fluctuation of water-surface they have a height at the crown of but 6 ins., the width at this point being 8.6 ft. A small drift gap, closed ordinarily by stop logs, provides an outlet for ice, a necessary provision, since the spillway forms the stream side of a forebay.

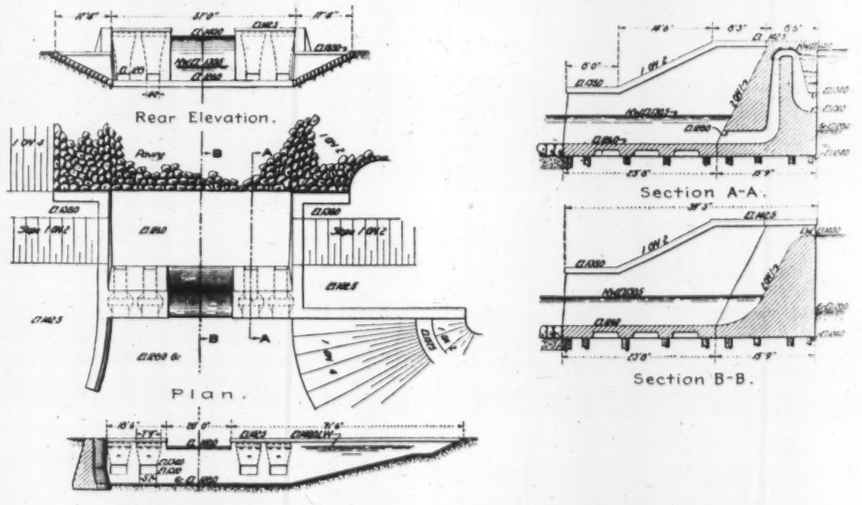

FIG. 2. DETAILS OF SIPHON SPILLWAY AT LOCK NO. 9, CHAMPLAIN CANAL.

*From the "Barge Canal Bulletin," September, 1910.

Electric Steel Refining.*

By D. F. CAMPBELL.†

The use of electricity for the refining of steel has now taken its place amongst established metallurgical processes, and many papers have been written on the subject of electric furnaces, but the author proposes to discuss briefly the general aspects of the subject, and what he considers the probable and possible developments in the immediate future in England. The electrode furnace is at present used in various works for the refining of steel from the Bessemer converter in the manufacture of rails and all classes of railway material and castings, and more commonly in connection with the basic open-hearth process for the manufacture of various products of intermediate quality, castings and tool steel of all kinds. These are the purposes for which it has been most widely adopted, notably in America, Germany and France, though it is also used for melting and refining charges of cold scrap of cheap quality for the manufacture of tool steel and small castings, and its high efficiency is now generally acknowledged. The refining of steel that had been previously melted was the first use to which the electric furnace was applied commercially; but now that single furnaces have been producing over 200 tons a day for more than 16 months, it is obvious that the field for the process has widened, and already many furnaces are in construction or operation in this country.

The author is of opinion that the electric furnace (electrode types) is especially suitable, and will be widely adopted, for any class of work in which raw materials of a high degree of purity are now used.

A wider application for rails and sections may occur when working in connection with the Talbot open-hearth tilting furnace, for the charge can be taken to the electric furnace as soon as the carbon is down, and the necessity of removing the sulphur and getting a teeming heat is avoided, as this is done in the electric furnace both economically and completely. Thus the capacity of the Talbot furnace is substantially increased, and this covers the greater cost of electric refining.

Again, in the case of a basic open-hearth plant, using 60% of molten pig iron and 40% of scrap, a 40-ton furnace might have 15 tons removed to the electric furnace for refining, and a similar charge put in every two hours. Thus the capacity would be increased, the quality improved, and, in addition, a reduction in the cost of raw materials can also be made in some cases, as a low quality of pig iron can be used.

Similar conditions occur when working in conjunction with an open-hearth plant for making castings, and a thoroughly dead melt and extreme fluidity can be obtained, while the commonest raw materials can be used and refined completely. This gives economy both in the amount of gits and runners, and also in the reduction of wasters. Even in the case of foundries engaged in ordinary open-hearth casting work, in which the margin of profit is now exceedingly small, the electric furnace is considered necessary for an improvement in quality, while in a small foundry making light and intricate castings from crucible steel, an economy of several pounds per ton may be expected to result from the adoption of the electric furnace, judging from the reduction of the costs in works in Germany where crucible furnaces were replaced by this process.

*From a paper before the Iron and Steel Institute at Boxton, England, Sept. 27.

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There is little doubt that crucible steel, Swedish billets, and products of intermediate quality, such as are used for the Sheffield trade and by tube-makers of Staffordshire and South Wales, can be economically replaced by steel refined by electricity and made in Middlesbrough, Cumberland, or the larger steel works in the Sheffield and Rotherham districts.

The use of the electric furnace is not likely to become general for steel-rail manufacture at the present time, except in cases where the conditions are exceptional. In certain cases, such as at South Chicago, it has been adopted for that purpose owing to economic conditions, notably the scarcity of good Bessemer ores and the demand for better rails. The electric furnace in such cases may save Bessemer plants from the scrap heap, or, at any rate, prolong the life of present installations, and at the same time make it possible to produce rails of a quality better than the best open-hearth steel, thus avoiding heavy capital expenditure.

In the electric furnace, almost any degree of refining can be economically effected, and the removal of sulphur, phosphorus and oxygen is especially easy. This is probably due to at least three causes: (1) The intense heating of the slag, which is the place at which refining takes place. Owing to this high temperature and the extreme fluidity of the slag, the rate of the refining reaction is very great, because the velocity of reaction rises very quickly for high temperatures, and not in direct proportion to the temperature. (2) The extremely basic slag that can be kept in a very fluid state, and the calcium carbide formed by the action of the arc on the calcareous slag, are especially advantageous for desulphurization. (3) The violent motion of the steel, which results from the convection currents produced in the bath, due to the two intensely hot areas caused by the arcs below the electrodes, increases the volume of steel exposed to the hot and fluid slag area, and hence the rate of refining.

The usual procedure for the use of the electric furnace in connection with the Bessemer converter is to charge the steel, holding back all slag in the ladle, after putting on the bottom of the furnace, lime and mill scale or iron ore. This produces an oxidizing or dephosphorizing slag, which may be carefully skimmed or poured off. On the bath of steel, carbon is thrown to carburize to any required degree, and then a second highly basic and desulphurizing slag is added. The arc acting on the calcareous slag produces calcium carbide, which may combine with sulphur to form calcium sulphide. As neither gases nor air enter the furnace, and the conditions are almost completely reducing, no sulphates are formed, a dead melt is easily obtained, and when the slag is molten and the requisite heat obtained, the steel is teemed. In the open-hearth or any oxidizing furnace these reactions cannot take place so completely and efficiently.

With steel from the basic open-hearth furnace, the procedure is similar, but when the quantity of phosphorus to be removed is small, it is only necessary to use one refining slag for the elimination of sulphur and any small amount of phosphorus remaining. The usual practice is to put the carbon necessary for carburizing in the bottom of the furnace and then add the steel, and the basic slag materials. As soon as the teeming heat is obtained, the necessary ferro-alloys are added and the steel will be completely refined.

Another point of interest is the rarity of blow-holes in electric steel when properly made, and this leads to the question of the cause of these troubles. It is well known that any ingot of steel when placed in a vacuum evolves nitrogen, and this is about equally true whether it be made in the crucible, the Bessemer converter, or the electric furnace. Blow-holes contain nitrogen, but this is probably not the cause. It is far more probable that they are due to the combination of oxides with the carbon in the process of cooling, and that the carbon monoxide so formed at a high temperature causes blow-holes in the cooling steel, and owing to the diminution of volume of the carbon monoxide on cooling, a partial vacuum is formed, and nitrogen is sucked into the blow-holes. In electric steel, oxides do not occur in any quantity, and consequently the prime cause of blow-holes is reduced.

Again, the quality of electrically refined steel is better than a material of similar chemical composition made in any oxidizing furnace. This is probably due to the reducing conditions under which it is finished.

It must not be forgotten in discussing these special qualities of electrically refined steel that some inferior material has been made by incompetent melters or in ineffective furnaces and that the electric, just as much as any other furnace, requires trained men, and most careful designing by metallurgists who have made a special study and had practical experience in this subject.

The question of the cost of applying this process, which must be considered before all others, is more difficult to discuss generally, owing to the great variety of conditions. The following are the chief points, all of which must be carefully considered in each particular case: (1) The possibility of saving in cost of raw materials, since the best qualities of steel can be made from impure raw materials. For example, in the case of refining steel from open-hearth furnaces in the South Staffordshire district, the use of local pig iron as compared with hematite iron would effect a saving of several shillings per ton owing to the high railway rates. (2) Possibility of increasing the output of present furnaces by the addition of electric furnaces with improvement of product. For example, in the case of Talbot and other open-hearth furnaces, where a large expense is incurred in the removal of sulphur and getting a teeming heat, the steel can be advantageously transferred to an electric furnace for desulphurization and the output materially increased. The Talbot or other tilting furnace is especially satisfactory owing to the facility with which charges can be transferred to the electric furnace, whenever required. (3) The cost of power and possibility of using blast-furnace or coke-oven gas, etc., will be the determining factor in regard to deciding whether, in the manufacture of steel, electric refining can be economically adopted. In the case of cheap power or valuable products, scrap may be economically melted and refined in the electric furnace at a current consumption of 700 to 800 kilowatt-hours per ton, or if the price of power be high, the steel may be merely desulphurized and deoxidized, after melting and dephosphorizing in a basic furnace, with a power consumption of 100 to 150 KW.-hrs. per ton. (4) The possible reduction of capital expenditure at certain works where the present products are not sufficiently good for modern specifications. This may involve the entire reorganization of the works, but it is often cheaper and more efficient to add an electric furnace to a Bessemer plant, than to replace the latter by open-hearth furnaces.

The author does not wish to compare the different types of electric furnace in this paper, but the figures given are taken chiefly from Heroult furnaces in America, England, Germany and France, as this type has been far more widely adopted, and is used in larger units than any other, and single furnaces are now refining 250 tons per day. This furnace is similar to a basic open-hearth furnace, and seems to present more simplicity and to embody more of the desirable features of electric furnace design than any other, which, in the author's opinion, are: (1) The best basic open-hearth design should be followed as closely as possible. A bottom homogeneous and solid and banks free from embedded electrodes is important, and above all simplicity of design. (2) All electric mechanism, in the form of generators, transformers, etc., should be entirely separate from the furnace, should work under ordinary conditions of standard electrical practice, and should be of standard design, so as to avoid all unnecessary risks and complications. (3) A high power factor must be maintained, thus reducing the capital cost of machinery, and increasing the general efficiency of the power house. (4) To avoid excessive cost of refractory materials, the roof should be protected from the direct radiation of the arcs by the electrodes themselves and the intensely heated area of slag should be as large as possible, to increase the surface of refining action. (5) The heat should be applied to the slag, as in the basic open-hearth furnace, and the temperature of the slag should be maintained above that of the steel, which allows of extreme basicity and fluidity being obtained and gives an intensely active refining action. The conditions in the furnace should be oxidizing, neutral or reducing, at will.

The adoption of electric refining will cause some readjustment in the steel trade. As soon as the Sheffield steel melter has become acquainted with the process and accustomed to the working of electric furnaces, electrically refined steel will largely replace ordinary crucible steel. This has already occurred in Germany and America, where electric furnaces are used to make all classes of special and high-speed steels, the usual practice being to refine metal taken hot from a basic open-hearth furnace. Large crucible plants and small open-hearth furnaces engaged in the manufacture of small and intricate castings, such as motor-car parts, etc., may be replaced by electric furnaces, because the high degree of fluidity and dead melt obtained is especially advantageous.

In many cases manufacturers of axles, guns, and tubes will abandon the use of Swedish raw materials, and refine steel made from low-grade ores, thus reducing the value of high-grade ore deposits and the quantity imported; for, by the use of electricity, Cleveland stone will produce a steel equal to the best hematite ores. The capacity of many Talbot and basic open-hearth plants will be increased and the quality of the product improved, while much of the power that is now going to waste will be utilized for steel refining.

From the electrical engineer's point of view, the electric furnace is an attractive load, as it is more or less in continuous operation. With electrode furnaces the power factor is 0.88 to 0.90, though much less with large induction furnaces. Single, two or three-phase current of any frequency from 20 to 60 has been used without any difficulty, though it is preferable in the case of a two-phase system to transform to three-phase current, which can be done without additional difficulty or expense. The load factor will be most favorable, the usual practice when refining, for example, in a 15-ton furnace, being to use 2,000 KW. for 20 minutes after charging, while the steel is being heated. The current is then reduced to about 1,500 KW. for 45 to 75 minutes until the steel is ready for teeming. There is then an interval of 10 to 15 minutes during which the furnace is teemed, fettled and charged, which allows the transformers or generators time to cool before the period of overload commences. Current fluctuations occur for a few minutes, while there is an evolution of gas from the steel which makes the bath boil up and touch the electrodes. This, however, is not sufficent to be objectionable, provided that the electrical machinery is properly designed for the purpose; the extent of these variations is not so great as in the case of many rolling mills, the fluctuations in voltage being only about 3% in the South Chicago works, where a 2,000-KW. furnace has been working steadily since May, 1909.

Developments in Train Lighting by Electricity.*

One of the most important changes in head-end practice (with a generating plant at the head of the train) is that which has been made on the C., M. & St. P. Ry., where the 110-volt, head-end, systems are being changed to operate at 64 volts in accordance with the recommendations of this Association a year ago. This change has not involved the purchase of any new generator equipment.

At the same time, another change of even greater importance was inaugurated. This is the change from the three-wire to the two-wire system of charging the storage batteries on the train. It has been applied to the 110-volt equipments as well as to those using 64 volts, and has been found to provide better charging of the batteries. It has been possible also to reduce the number of cells required in each set of batteries from 54 to 32. When the full load is on, the batteries always receive a slightly higher voltage than the lamps, owing to the line drop. It is not expected that the batteries will be charged at this time, but experience has shown that when they have been seriously depleted they do receive a certain amount of charge.

In the later hours of the night when the lamp load has fallen off to perhaps a third of its former value, a connection is made in the front end of the train between the "lamp negative" line and the generator. This connection is, however, made through a variable resistance, so that the voltage on the lamps may be kept constant. The switch at the rear of the train connecting the "lamp negative" and "dynamo negative" lines is opened.

The generator voltage is now raised by altering the resistance by means of a rheostat in the baggage car. By having the resistance in the lamp circuit of sufficient size it is possible to keep the lamp voltage constant at 64 volts while that on the battery circuit is raised to 80. In this way the batteries can be charged to full capacity without injury to the lamps. As the lamp current is about 40 amperes after 11 p. m., and the generator capacity over 120 amperes, it is possible in this way to have a charging current of 20 amperes flowing into each of the batteries.

There might appear to be some danger with the two-wire system that the lamp voltage would fall off seriously at the end of the train, but in practice the drop has been found to be so slight that it can be disregarded. Also it might appear that higher voltage on the forward batteries would cause them to be charged heavily at the expense of those behind, but this also has not proved a serious difficulty.

In axle lighting, rubber belts are still used most extensively, but balata belting is being used to some extent and several chain drives have been tried with various degrees of success.

The use of ampere-hour meters has increased very greatly and should be extended to cover all train lighting equipment. There is no other accurate means of determining whether batteries are being overcharged or undercharged, and whether current is being used wastefully or economically. The duplex train meter, recording both charge and discharge on the same instrument, is the type best adapted to car lighting service.

The installation of ampere-hour meters on the batteries of the C., M. & St. P. Ry. has been of great assistance in determining just how much charge is necessary. Formerly this was guessed at roughly from the results of tests of the specific gravity of the electrolyte at terminal points. From the ampere-hour meter readings during last summer it was found that the batteries on the trains between Chicago and Minneapolis received sufficient charge in going one direction so that they did not require any charging on the return trip. A considerable steam saving was effected through this discovery.

An electric lighting instruction car that has been put in service on the Pennsylvania Ry. is fitted with all the equipment used in head end, axle-generator and straight storage lighting. It will be used in the same way as air-brake and steam-heat instruction cars.

*Abstract of the report of the Committee on Train Lighting Practice, presented at the annual meeting of the Association of Railway Electrical Engineers at Chicago, Sept. 27, 30.

How to Run in Transition Curves Without Tables.

By C. P. HOWARD,* M. Am. Soc. C. E.

There are a number of fieldbooks and tables for transition curves which are more or less satisfactory to those who use them, but an ordinary spiral of given length can be run in without fieldbook or tables.

When running in by transit the main thing is to put in the intermediate deflections with transit *at one end.* Beyond this it is only necessary to know a few important characteristics of the spiral (practically the cubic parabola, within the limits of ordinary railroad practice). The principal facts to be remembered are:

1. The total angle, I, of spiral is equal to its length multiplied by half the degree of curve; that is, calling D the degree of the circular curve and L the length of the spiral $I = \frac{1}{2}\ L\ D$, or where L is in feet $I = L D/200$.

2. The total deflection angle at the tangent end of spiral is one-third the total angle I. At the curve end it is two-thirds; or Angle $T = \frac{1}{3}\ I$; angle $C = \frac{2}{3}\ I$.

3. Deflections from the tangent end to points on spiral are as the squares of their distances from tangent end.

4. The middle point of spiral bisects the gap, p, between the $P.\ C.$ and tangent.

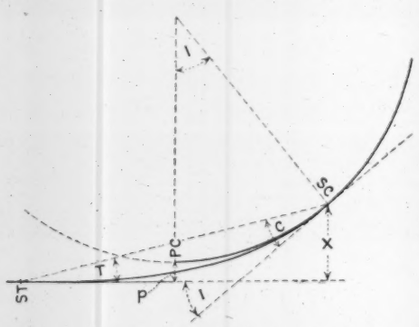

Diagram of Transition Curve.

EXAMPLE.—Approaching the curve from the tangent; degree of circular curve $D = 6°\ 00'$; length of spiral $L = 240$ ft.; $P.\ C.$ of circular curve to be opposite station 38 + 20.

The ends of spiral by Principle 4 will be 120 ft. each way from the $P.\ C.$, making the tangent end, $S\ T$, at 37 + 00 and the curve end, $S\ C$, at 39 + 40. Suppose we run it in by chords of any convenient length, say 6 chords of 40 ft. Then by Principle 1 the total angle I of the spiral is equal to 240 ft. of 3° curve = 7° 12'. By Principle 2, with transit at $S\ T$ the total deflection angle to $S\ C$, the curve end of Spiral, is $T = \frac{1}{3}\ I = 2°\ 24'$. By Principle 3 the deflection for each intermediate chord point is to the total deflection as the square of its distance to the square of the whole distance. Taking the distance from $S\ T$ in fractions of the total length we multiply 2° 24' by $(1/6)^2$, $(1/3)^2$, $(1/2)^2$, $(2/3)^2$, and $(5/6)^2$ to get deflections to the intermediate chord points, making

37 $S\ T$	
+ 40	0° 04′
+ 80	0° 16′
38 + 20	0° 36′
+ 60	1° 04′
39	1° 40′
39 + 40 SC	2° 24′

With transit at $S\ C$ and backsight on $S\ T$ turn the angle C, or $\frac{2}{3}\ I = 4°\ 48'$, to get on the common tangent to circular curve and spiral. That is all there is to it. If, however, it is desired to locate points at the even stations and + 50's, the deflections would be figured similarly. The distances to intermediate points being 50, 100, 150 and 200, their deflections would be 2° 24' multiplied by $(50/240)^2$, $(100/240)^2$, $(150/240)^2$, and $(200/240)^2$.

If we approach the spiral from the curve, we note another characteristic;

5. Starting at the curve end the spiral diverges from the circular curve produced the same as it does from the tangent produced when starting at the tangent end.

Therefore to get the deflections from the curve end of spiral we compute them the same as from the tangent end, *except that* we subtract them from the deflections for the circular curve produced instead of turning them from the tangent.

For instance, in the example above if we wish to run in the deflections from the curve end, we start with a tangent to the curve at $S\ C$, write out the deflections for the chord points on the circular curve produced, and subtract the deflections figured above thus:

Station.	Circular Curve.	Deductions.	Spiral.
37 S T	7° 12′	2° 24′	4° 48′
+ 40	6° 00′	1° 40′	4° 20′
+ 80	4° 48′	1° 04′	3° 44′
38 + 20	3° 36′	0° 36′	3° 00′
+ 60	2° 24′	0° 16′	2° 08′
39	1° 12′	0° 04′	1° 08′
39 + 40 S C			

Then having put in the spiral by deflections 1° 08', 2° 08', 3° 00', 4° 48', we move transit to tangent end, $S\ T$, and with backsight on $S\ C$, turn the angle $T = 2°\ 24'$ to get on tangent.

The division of the spiral into equal chord lengths has the advantage of using the same deflections no matter which way we run it, turning from the tangent in one case and from circular curve deflections in the other.

OFFSETS.—If it is desired to compute the offsets from the tangent, the following additional characteristics may be noted:

6. Offsets from tangent to points on the spiral are as the cubes of their distances from the tangent end. This is indicated by the name "cubic parabola." The distances may be taken approximately as measured on the center line of spiral.

7. Offsets from the circular curve produced to points on the spiral are also as the cubes of their distances from the curve end of spiral, being the same as offsets from tangent to spiral for corresponding distances from the tangent end.

8. The gap, p, between tangent and $P\ C$ of the circular curve is one-fourth the offset, X, from tangent to end of spiral.

The main offset, X, at the end of spiral is evidently equal to the sine of the angle T times the long chord of spiral, and as the chord nearly equals the length of spiral, approximately:

$$X = L \sin T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)^*$$

and by Principle 8 the gap, $p, = \frac{1}{4} X$.

If the transitman happens not to have a table of sines with him, he need not worry, so long as he remembers the sine of 1° 00'. As the sines of angles are practically proportional for any probable value of T, he has simply to multiply T in degrees and decimals by .01745.

Occasionally, on location where the profile is rough, it may not be possible to see from one end of the spiral to the other. In this case, perhaps the simplest and easiest way is by offsets as follows:

Offset the distance $p = \frac{1}{4}\ X$ from tangent to $P.\ C.$ of circular curve, or vice versa, and put in the points $S\ T$ and $S\ C$ at distances $\frac{1}{2}$ each way. For points on the half-length of spiral next $S\ T$ offset from the tangent, and for points on the other half offset from the circular curve.

For instance, in the preceding example the main offset is $X = L \sin T = 240 \sin 2°\ 24' = 10.05$, and $p = \frac{1}{4}\ X = 2.51$.

The offsets from the tangent to spiral, according to the cubes of their distances from $S\ T$ in fractions of L, are X multiplied successively by $(1/6)^3$, $(\frac{1}{3})^3$, $(\frac{1}{2})^3$, etc., making 0, 05, 0.37, 1.255, etc.; but we need only these three. The offsets from the circular curve for corresponding points and distances from $S\ C$ are the same, namely, 0.05, 0.37, and 1.255, the last offset 1.255 each case being the offset to the middle point of spiral at the $P.\ C.$ of circular curve. Added together they make the gap $p = 2.51$.

Approaching the curve from the tangent and reading up the page, curve being to the left, notes may be shown as follows:

Station.	Def.	Offsets.
39 + 40°	3° 36′	S C, 0.0
39	2° 24′	0.05 R
+ 60	1° 12′	0.37 R
38 + 20°	Offset 2.51′ L to P.C 6° L (spiral 1.25)	
+ 80		0.37 L
+ 40		0.05 L
37°		S T, 0.0

OTHER POINTS ABOUT THE SPIRAL.—If the gap, p, between $P.\ C.$ and tangent is given the length of spiral, L, may be obtained approximately by the rule of thumb,

$$L = 371 \sqrt{\frac{\overline{P}}{D}}$$

taking L to the nearest foot.

A suggested length for spirals is: elevation of main curve in inches multiplied by speed in miles per hour.* A six-degree curve elevated 6 in. corresponds to a speed of 39 mi. per hr. Multiplying this speed by 6, we would get a length of 234 ft.; or 258 ft. for 43 mi. per hr., which is 10% excess speed. Where practicable, longer spirals might be of some advantage in giving a longer run off for the elevation.

SUGGESTIONS AS TO TRACK CENTERS.—Attention should be called to the necessity for accurate instrumental work in running the track centers, and to the doubtful advantage of putting the points very close together. For instance, on a spiral 360 ft. long, one or two points may be 300 ft. or more from the transit. An error of ½ minute in deflection in that distance would throw the point off 0.00145 × 3 = .043 ft. If the centers are 50 ft. apart, one center off line that much would increase the middle ordinate of 100 ft. by the same amount, changing the degree of curve 0° 12'; but if centers are 25 ft. apart, it would change the degree of curve 0° 48' for 50 ft., and perhaps give the trackman a poor idea of the transitman's ability, especially if the next center and others are similarly off in opposite directions. However, if the transitman has any doubt of the accuracy of points at the far end of spiral, he may readily check back on one or two points with transit at the other end.

It may also be suggested as a good plan in running track centers between two hubs on a curve or spiral, that the chaining be done *towards* the instrument so that any error in distance will fall at the instrument instead of at the far end, where the line of sight is at a considerable angle across the track.

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*The main offset X = L sin T is more correctly X = C sin T; C being the long chord of spiral, whence p = ¼ C sin T. The difference is hardly appreciable. The long chord of spiral is approximately that of a simple curve of same length whose degree of curve is half that of the main curve. The error in value of p, using L instead of C, for certain spirals of different lengths and degrees of curve is as follows:

Degree.	I.	Length L.	Error in p.
4°	7° 12′	360′	0.0027 ft.
6°	7° 12′	240′	0.0016 ft.
10°	10° 00′	200′	0.0038 ft.
10°	12° 30′	250′	0.0098 ft.

It will be observed that the error does not approach 0.01 ft. except for the 10° curve with total angle of 12° 30′.

*This is suggested by Mr. J. R. Stephens ("The Six-Chord Spiral," Eng. News Pub. Co.), and where longer spirals may be desired, he suggests a further rule of thumb which would give lengths 25% greater.

Notes from Engineering Schools.

LEWIS INSTITUTE.—This Chicago institution has issued a pamphlet containing an outline of its evening session technical courses, including engineering principles and engineering mathematics. The courses cover civil, mechanical, electrical and chemical engineering, steam and gas engine practice, structural steel and concrete designing, laboratory and drafting room work, etc. There are special courses in architectural and mechanical drawing. The courses in shop work cover not only the mechanical work, but the drafting and computation work in connection with it; they include both machine shop and wood shop work.

COLUMBIA UNIVERSITY.—A series of public lectures on sanitary engineering and public health will be given during the months of October-January. The lectures will take up the development of public health work, water pollution and purification, clean streets as a factor in public health, the collection and disposal of municipal waste, communicable diseases, flies and other insects as carriers of disease, and the tuberculosis problem. A committee was appointed about a year ago to consider the feasibility of establishing at Columbia a school of sanitary science and public health, but as yet nothing definite has been accomplished.

A POWDER MILL EXPLOSION at the plant of the American Powder Co. near Maynard, Mass., Oct. 9 wrecked the press mill. Occurring as it did on a Sunday when only a solitary watchman was about, this accident is the first powder mill explosion for some weeks past in which no one was killed.

A WATERFRONT FIRE AT MONTEVIDEO, Uruquay, Oct. 4 destroyed the new docks, the customs house and quantities of European and American imports. The loss is estimated at about $1,500,000.

AN EXPLOSION AT THE NAVY YARD at Washington, D. C., Oct. 4, killed two men who were preparing fuses for armor-piercing projectiles. A third man who was in the small building where the fuses were being made at the time was badly injured. Reports state that in the preceding five months 6,000 fuses had been made at the Washington yard without accident.

A STEAM-HEATED PASTEURIZER EXPLODED at Pittsburg, Pa., Oct. 6, at the plant of Edward E. Rieck & Co., milk dealers. One man was killed and three injured.

AN ELEVATOR ACCIDENT Oct. 6 at London, Ont., in the biscuit factory of D. S. Perrin & Co., killed one man and injured three others, of whom two are not expected to survive. As the elevator was going down it struck a truck which had been pushed out so that it projected into the shaft at one of the upper floors. The elevator was stopped by the truck, but the cable continued to uncoil so that it slackened above the car. Then the car was in some way suddenly released and dropped freely till the slack was taken up. The cable failed under the strain thus put upon it and the car fell several stories.

FOREST FIRES IN MINNESOTA in the northern part of Beltrami Co. and the eastern end of Roseau Co., driven by the high wind of Oct. 8-9, destroyed a half-dozen of the small towns in the region served by the Canadian Northern Ry. Among the towns burned were Beaudette, Spooner, Swift and Zipple, all in Minnesota, and Sprague, Manitoba. A number of other towns were partly burned, including Rainy River, Pinewood and Stratton, in Ontario, and Williams, Roosevelt and Warroad, in Minnesota. The number of persons killed is estimated at 1,000, the remains of 300 of whom have been already recovered. The property loss is estimated at about $50,000,000.

AN EXPLOSION IN A COAL MINE at Starkville, Colo., shortly after 10 p. m., Oct. 8, entombed about 50 miners. Reports state that the mine had not been regarded as dangerously gaseous and that open lamps were permitted, also that no explosives were used in the mine. Reports dated Oct. 10 state that, up to that time, all efforts of rescue parties to penetrate to the men caught in the mine had failed. The mine is the property of the Colorado Fuel & Iron Co.

Six of the 70 or more miners imprisoned in the mine near Muzquiz, Coahuila, Mexico, Sept. 30, were rescued alive Oct. 4. A heavy fall of rock, according to reports, had walled them in and protected them from suffocation by after-damp. On Oct. 5 the bodies of 35 of the men killed had been brought to the surface.

QUEBEC BRIDGE TENDERS.—Tenders for the construction of the superstructure of the Quebec Bridge closed at one o'clock, Saturday, Oct. 1, 1910. Tenders were received from the following firms: 1. St. Lawrence Bridge Co., Ltd., of Montreal, representing a combination of the Dominion Bridge Co. of Montreal, and the Canadian Bridge Co., of Walkerville. 2. The British Empire Bridge Co., Ltd., of Montreal, representing a combination of the Cleveland Bridge and Engineering Co., Ltd., of Darlington, England, and the Patent Shaft & Axletree Co., of Wednesbury, England. 3. The Pennsylvania Steel Co., of Steelton, Pa., U. S. A. 4. Maschinenfabrik Augsburg-Nürnberg A. G., of Gustavsburg, Germany.

Most of the firms in addition to tendering on the design of the Board of Engineers have presented designs of their own and tenders on same, as they were allowed to do by the specifications. The Minister of Railways and Canals has submitted the tenders and plans to the Board, who will study them and report back to the Minister. No information in regard to the prices will be given out until after the Board has made its report, which, in view of the large number of plans and alternative tenders received, will probably not be for several weeks.

A NEW ROCK-TUNNELING RECORD was made during August in the Laramie-Poudre Tunnel, in Colorado, of the Laramie-Poudre Reservoir & Irrigation Co. As stated in our issue of July 28, 1910, a record figure of 519 ft. advance was made in May, 1910, in the East heading. It is now reported that the same heading advanced 527 ft. in August. The rock penetrated was a hard close-grained red and gray granite. The cut holes are drilled 12 ft. deep and the others 10 ft., using Leyner air drills. They are loaded each with seven sticks (1¼ × 8 ins.) of 100% powder, and filled to within 2½ ft. of the top with 60% powder. The tunnel is to be 12,000 ft. long. Fuller details were given in the article above noted. J. A. McIlwee is the contractor. A bonus is paid to the men for progress exceeding 250 ft. in a month. The contractor will also earn a heavy bonus for completing the tunnel in less than two years, which at present rates of progress seems likely.

PORTLAND CEMENT CUPELS for assaying ores have been tested by Messrs. T. P. Holt and N. C. Christensen, at the School of Mines of the University of Utah, Salt Lake City, and are reported in the "Engineering and Mining Journal" of Sept. 17. Their findings are summarized in the following five headings:

(1) Portland cement presents a cheap and convenient substitute for the bone ash commonly used for cupels.

(2) Neat cement with from 6 to 10% moisture gives a strong cupel that does not check and will absorb its own weight of litharge.

(3) The silver loss due to absorption is about the same as for 90-mesh bone ash, the difference being insignificant compared with that due to a slight increase in temperature.

(4) Cupels made of a mixture of cement and bone ash gave a smaller silver loss than either one alone, and the physical properties of the cupel are also superior.

(5) The process of cupellation is dependent upon the fact that the capillarity of the cupel is "wet" with respect to the litharge, and "dry" with respect to the lead and the precious metals. Consequently the physical surface of the cupel has an important bearing on the absorption losses.

LEVELS OF THE GREAT LAKES are reported by the U. S. Lake Survey Office, Detroit, under date of Sept. 10 for the month of August as follows:

	Superior.	Mich. & Huron.	Erie.	Ontario.
Elevation Aug. 1910 (above sea-level, New York)	601.96	580.35	572.09	246.05
Below Jul. 1910	—0.07 (higher)	0.15	0.26	0.24
Below Aug 1909	0.44	0.70	0.71	0.77
Below average August of last ten years....	0.99	0.85	0.62	0.54
Below high stage	1.39	3.16	2.02	1.90
(Of date) ...	(Aug. '90)	(Aug. '76)	(Aug. '76)	(Aug. '08)
Above low stage	0.08	0.47	0.71	1.70
(Of date) ...	(Aug. '92)	(Aug. '36)	(Aug. '95)	(Aug. '95)

TRENCH EXCAVATION IN ROCK by the use of pneumatic hammer drills has been found an improvement upon hand drills and steam drills at Gloucester, Mass., which city is built largely on a solid granite formation. A portable air compressing plant purchased by the Street Commission for this work has a 15-HP. gasoline engine geared to a Sullivan compressor, both being mounted on a timber bed with four wheels. The weight of the outfit is about four tons. The compressor has a capacity of 96 cu. ft. of free air per min. at 165 r. p. m., the pressure being 80 to 100 lbs. There are two hammer drills, one for 1¼-in. holes 3 ft. deep, and the other for 1¼-in. holes 5 ft. deep. Holes 5 ft. deep in hard rock have been drilled in 30 mins., with 20 mins. as the best record. In 16 hours' work, the smaller drill put in 47 ft. in 25 holes from 19 to 36 ins. deep, and the larger one put in 19 ft. in 5 holes 32 to 60 ins. deep. The time includes loading, shoreing and all details. These figures are given in the "Mine and Quarry" publication of the Sullivan Machinery Co. The plant is used also for drilling at the city's rock quarry. A similar method of working was described in our issue of Sept. 9, 1909. This was at Bloomington, Ind., where two portable compressors (mounted on skids) were driven by a traction engine. With 110-lb. receiver pressure the drills could be worked at a distance of 1,500 ft. from the compressor.

A NEW TENSILE-IMPACT MACHINE was described by Blount, Kirkaldy & Sankey before the Institution of Mechanical Engineers (London) in a recent paper, together with tests made on the machine. Its essential feature is that error due to the inertia of the jaws is eliminated. The upper jaws are in a crosshead falling between guides, and the specimen with the impact weight attached to it by the lower jaws is attached to the crosshead when in its upper position and falls with it. A pair of anvil blocks arrests the crosshead at the bottom of the fall, and the inertia effect of the weight on the lower jaws is alone active to rupture the test-piece. The velocity of fall before and after rupture is measured by a time record on a motor-driven sheet of paper, where electrically actuated pens make a record of the time of opening the trigger, the time of passing a contact just below the anvil, and the time of passing a second contact 10 ft. below. A vibrating pen marking 40 vibrations per second, and another pen moved by a half-second pendulum, give an accurate time scale, so that the time of fall above and below the anvil can be computed. It is found necessary, for consistent results, to adjust the breaking energy so that it will not much exceed the work required to rupture the test-piece. Weights ranging from 10 up to 20 lbs. are used, and the height of fall can be varied up to 40 ft. The guides have clearance so that normally a free fall is obtained. Tests with the apparatus are held to show that the work of fracture is about 50% higher than that obtained by static tensile test, and does not vary greatly for different kinds of steel; also it does not detect brittleness due to small amounts of phosphorus.

TAXES ON AUTOMOBILES in Great Britain under the new law passed by Parliament this year are assessed at the following rates:

Horse-power of Car.	Annual tax.
Not over 6½	$10.25
6½ to 12 HP	15.40
12 to 16 HP	20.50
16 to 26 HP	30.80
26 to 33 HP	41.00
33 to 40 HP	51.25
40 to 60 HP	101.85
Exceeding 60 HP	202.70
Motor bicycle or tricycle	4.85

Physicians using an automobile in their practice pay one-half the above tax and motor cabs are not taxed. Of the revenue raised by the new tax a part is to be devoted to a fund for road improvement to be expended by a Government Commission.

CONCRETE CASINGS FOR WOODEN PILES have been used with great success in wharf and bulkhead construction on the San Francisco water front by the Board of State Harbor Commissioners. This is the type of construction used at the Bocas del Toro wharf at Panama, as described in Engineering News, Jan. 13, 1910, p. 30. These casings are reinforced-concrete hollow cylinders cast in any required size on shore and allowed to set there until needed. In the application of these casings the wooden pile, of whatever size and length required, is first driven to the desired depth, and the casing then slipped over the pile, and in turn, is driven as far as desired. Then the interior of the casing is pumped out, the mud or sand removed to the required depth and the annular space around the wooden pile filled with concrete. For the bottom of the casings special shoes are provided which fit reasonably close around the wooden pile and serve to space the casing around the pile thus ensuring a uniform thickness of concrete filling and preventing any large amount of mud or sand from entering the casing during the driving. In the San Francisco work casings 24 ins. in diam. and from 22 to 56 ft. long have been used. For longer lengths a special splice is provided. This particular type is patented by Mr. F. A. Koetitz, of the Pacific Construction Co., who installed them at San Francisco.

WELL WATER SUPPLIES IN ILLINOIS.—It is usually believed that any community with a population of over 1,000 should have a common water-supply. Many cities in Illinois with less than 1,000 inhabitants have municipal supplies. Only a few with more are without one, and most of these are considering the question of installing a water-works system. For individual supplies wells have long been the most satisfactory source. In Illinois these may be shallow wells 15 to 30 ft. deep, wells in drift 70 to 150 ft. deep, or wells in rock 500 to 2,000 ft. deep. Probably the number of supplies from shallow wells is greater than that of all other kinds put together. The number of persons served by such wells, however, is not over half the population of the State, for very few large supplies are obtained from this source.

Over a great part of the State, wells 70 to 150 ft. deep furnish an abundant supply of water. In many places this water is of such a nature that on exposure to the air it becomes turbid and furnishes opportunity for the growth of microscopic organisms which give unpleasant tastes or odors to the water. The city supplies at Champaign and Bloomington are of this type. Water from shallow wells is subject to pollution, and in any fairly densely populated community almost certain to be unsafe for drinking, but wells deep in the drift give a water that is perfectly safe.

Several cities obtain a supply of water from deep wells in rock. At most of the cities as Sterling, Rockford, and Elgin, this water, in addition to being perfectly safe to drink, contains less dissolved mineral matter than surface waters or shallow well waters in the same neighborhood. These deep-well waters may be drawn upon at a normal rate for a very long time without showing any loss of head, but nearly everywhere the quantity which can be obtained, even by increasing the number of wells, is decidedly limited. This has driven many cities to adopt surface water as a source of supply.—From a report by Mr. C. D. Collins on "The Quality of the Surface Waters of Illinois"; Water Supply Paper No. 239, U. S. Geological Survey, Washington, D. C.

WIND-POWER ELECTRIC PLANTS have been installed by the Allgemeine Elektricitäts Gesellschaft of Berlin, Germany, since 1904. According to their September bulletin four such plants have been installed and

several others are being built. One was built in 1904 on an estate near Ebenhausen, producing power for agricultural machinery, but also feeding several incandescent lamps. Later a lighting equipment was built at Husum, furnishing current for 42 incandescents and 8 arcs. A very large one was built in 1909 at Jablonken, supplying over a hundred lamps and a small 2-HP. laundry motor. Still more recently a lighting plant was put in at Marienwerder. No details of the equipment are given, but apparently storage batteries with end-cell switch control are used.

A NEW UNION STATION AT CINCINATI, OHIO, is to be built by the Cincinnati Union Depot & Terminal Co., which has been granted a franchise by the city. The present stations are flooded at high-water periods of the Ohio River and some of them have inconvient locations. The proposed station will be between Third and Pearl Sts (and near the Post-Office), with a building 400 × 200 ft. on the north side of Third St. and trainsheds 309 ft. wide to the south side of Pearl St. The arrangement provides for 14 tracks, with an 8-ft. platform for passengers between each pair of tracks, and a 13-ft. platform for handling baggage, mail and express. The station will have through tracks, but as there are few through trains, it will serve practically as a double terminal station, with trains entering and departing at each end. Thus it will have practically 28 tracks to accommodate the traffic, which is said to aggregate 276 inbound passenger trains daily. A large office building will be erected over the station, about half of which is expected to be occupied by the various railways. There will be also space for warehouses, stores, express companies, etc. At each end of the station will be a large coach yard. The project includes railway lines running east and west from the station, connecting with the various main lines and providing for interchange of traffic. In addition, there will be a separate building to accommodate the numerous electric interurban railways which reach the city. The plans of the station and other works are now being prepared. Mr. A. S. White is President of the company, and Mr. John E. Bleckman, Vice-President, has furnished us with information as to the project.

THE TOPOGRAPHIC MAPS named below were issued by the U. S. Geological Survey during April, May, June and July, 1910:

Antietam, Md.-Va.-W. Va.
Bedford, Pa.
*Bisbee, Ariz.
Bloomington, Ind.
Houldin, Cal.
Breckenridge, Colo.
*Burnet, Tex.
Carson, Sink, Nev.
Castle, Cal.
Clay, W. Va.
Conesville, Ohio.
Danforth Hills, Colo.
Eugene, Ore.
Fish Springs, Utah
Frazeysburg, Ohio
*Furnace Creek, Cal.-Nev.
Galt, Cal.
Gassaway, W. Va.
Grand Hogback, Colo.
Granville, Ohio.
Headreach, Cal.
Higdon, Mo.
Isleton, Cal.
Jensen, Utah-Colo.
Jersey, Cal.
Linden, Tex.
Macon, Mo.
Montevallo, Ala.
Montgomery, W. Va.
Mound, La.
Pawhuska, Okla.
Philo, Ohio.
Pleasant Grove, Cal.
Rangeley, Colo.
Ray, Arizona.
Rio Vista, Cal.
Rock Springs, Wyo.
Stony Creek, N. Y.
*U. S. relief map.
*Waterloo, Wis.
White River, Colo.
Woodbridge, Cal.
York, Pa.
Yosemite National Park, administration map.
Zelienople, Pa.
Zillah, Wash.

*New editions.

The United States relief map is 18 × 28 ins. and sells for 10 cts.; the administrative map of Yosemite National Park sells for 25 cts.; the other maps sell for 5 cts. each. A discount of 40% is allowed on purchases of topographic maps amounting to $5 or more at the retail rate. Payments should be made by certified check or by postal or express money order, payable to the Director, U. S. Geological Survey, or in cash—the exact amount.

THE KENTUCKY AND INDIANA BRIDGE over the Ohio River at Louisville, Ky., is to be rebuilt for heavier loads and greater traffic capacity. The new structure is designed for Cooper's E-65 loading. The two long spans (over the Kentucky and Indiana channels, respectively) will be 620 ft. long. It will be a double-track structure, with roadways outside of the trusses. It will be supported on new concrete piers, and the contract for the substructure has been let to the Foster, Creighton & Gould Co., of Nashville, Tenn. The bridge is owned by the Kentucky & Indiana Bridge & Railway Co., of which Mr. W. M. Mitchell is Manager and Chief Engineer. The introduction of electric traction for local traffic over the bridge, as auxiliary to the regular steam railway traffic, was described in our issue of Aug. 29, 1895.

The old bridge was built in 1881-86, with the late C. Shaler Smith as Consulting Engineer and the late John MacLeod as Chief Engineer. The superstructure was designed by Mr. Charles Macdonald, who took the contract for its construction. It consists of through-truss spans, with a single track and roadways. The spans beginning at the Kentucky end, are: (1) 260-ft. anchor-arm, (2) 483-ft. cantilever span, (3) 360-ft. anchor span (across Sand Island) for the two adjacent cantilever spans, (4) 480-ft. cantilever span over the main channel, (5) 260-ft. anchor arm, (6) 365-ft. swing span, (7) 240-ft. truss. The live load for which it was designed consisted of two 57-ton locomotives of the 2-8-0 class followed by a train load of 2,240 lbs. per ft., with 1,200 lbs. per sq. ft. for the roadways.

THE KANSAS CITY UNION STATION and the terminal facilities in connection with it are now under way, after some years of protracted negotiations between the several railways interested and between the Kansas City Terminal Ry. Co. and the city. The station and the entire terminal system will be owned, built and operated by the Kansas City Terminal Ry., of which Mr. H. S. Kinnear, M. Am. Soc. C. E., is President, and Mr. John V. Hanna, M. Am. Soc. C. E., is Chief Engineer. The new passenger station will be located near 23d St. and Baltimore Ave., on the south side of the city and approximately two miles from the old station. The city streets will connect with a broad plaza in front of the station, and the main entrance to the building will be from this plaza. Mr. Jarvis Hunt, of Chicago, is architect for the building. The approximate area occupied by the new station, its tracks and immediate appurtenances in the way of express and mail facilities, approaches, etc., is 56 acres. The present station with its tracks occupies 6.9 acres. As to the freight arrangements, the company will have a freight yard in Kansas City, Kan., for which it now has real estate to the extent of about 43 acres; half of this will be occupied at once and the balance later as business requires. It has about 30 acres to be used for the construction of a coach yard, near the new station, and approximately 80 acres east of the Big Blue River (about five miles from the station) which can be developed for yard, shop and round-house purposes. In general the agreement between the company and the city provides for the vacation of streets to be occupied by the terminal company's tracks and for the practical elimination of all grade crossings on these tracks.

Personals.

Mr. Ralph Budd has been made Chief Engineer of the Spokane, Portland & Seattle Ry. to succeed Mr. T. H. Croswell, resigned.

Mr. N. L. Moon has resigned his position as Superintendent of the Wyoming, Pa., division of the Lehigh Valley R. R. He has been succeeded by Mr. C. J. Shea, recently Division Superintendent at Auburn, N. Y.

Mr. J. J. Martindale, Assoc. Am. Inst. E. E., formerly Chief Engineer of the Northern Construction Co., of Lansing, Mich., has become Electrical Engineer of the Michigan United Rys., with headquarters at Jackson, Mich.

Mr. James S. Whipple, Forest, Fish and Game Commissioner of New York State for the past six years, has resigned as the result of a report rendered by the special commission appointed by Governor Hughes to investigate his administration.

Mr. L. D. Blauvelt, M. Am. Soc. C. E., formerly General Manager and Chief Engineer of the San Luis Southern Ry., has been appointed Chief Engineer of the Denver, Northwestern & Pacific Ry., with headquarters at Room 118, Majestic Bldg., Denver, Colo.

Mr. Walter I. Slichter, M. Am. Inst. E. E., has left his position in the engineering department of the General Electric Co., with which he had been since 1896, to become Professor of Electrical Engineering at Columbia University. Mr. Slichter is a graduate of Columbia, class of 1896.

Mr. Charles Whiting Baker, Editor-in-Chief of Engineering News, returned to this country on the steamship "St. Paul," Oct. 8, after a four months' stay in England and the Continent. Mr. Baker has completely recovered from the attack of scarlet fever which had kept him in quarantine near Birmingham, England, since the latter part of July.

Mr. F. D. Nash, Assoc. M. Am. Soc. C. E., until recently Division Engineer of the Bureau of Public Works of the Philippine Islands, has been appointed Principal Assistant Engineer of the sewer and water-works construction for the City of Manila, P. I., and has also taken over temporarily the duties of the Superintendent of Water Supply and Sewers.

Mr. C. W. Kouns has been appointed General Manager of the eastern lines of the Atchison, Topeka & Santa Fe Ry., with headquarters at Topeka, Kan., to succeed James E. Hurley, whose death was noted in our issue of Aug. 18. Mr. F. C. Fox, formerly Superintendent of the eastern lines, has been appointed to succeed Mr. Kouns in his former position as General Manager of the western lines.

Obituary.

George Poole, President of the Poole Engineering & Machine Co., of Baltimore, Md., died Sept. 24.

C. W. Reinoehl, of Steelton, Pa., Superintendent of the frog and switch department of the Pennsylvania Steel Co., was killed at Buena Vista, Atlantic Co., N. J., Oct. 9 by the overturning of an automobile which he was driving.

Charles H. Smith, President (and founder) of the Western Wheeled Scraper Co., died at Aurora, Ill., on Sept. 25. He was born in Ohio in 1842, and in 1862 enlisted in the Fourth Iowa cavalry for service in the Civil War. At the close of the war he entered railway service as a roadmaster's clerk on the Chicago, Burlington & Quincy Ry., and afterwards had charge of tracklaying on several extensions of that road. In 1877 he and Mr. W. S. Dick-with, with whom he was associated on the railway, bought the patents for the Schultz scraper, and organized the Western Wheeled Scraper Co., with works at Mt. Pleasant, Iowa. About 1892, the company established a larger works at Aurora, Ill., and took up the manufacture of other grading machinery.

Engineering Societies.

COMING MEETINGS.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 18-20. Annual convention at Denver, Colo. Secy., C. A. Lichty, Chicago & Northwestern Ry., Chicago, Ill.

AMERICAN GAS INSTITUTE.
Oct. 19-21. Annual meeting at New York City. Secy., A. B. Beadle, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Oct. 21-Nov. 15. Canal Zone meeting. Secy., R. W. Raymond, 29 West 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Oct. 24. Annual convention at Baltimore, Md. Secy., P. S. Miller, 29 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 15. Annual meeting at Washington, D. C. Secy., Wm. H. Connelly, Interstate Commerce Commission, Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 16. Semi-annual meeting at St. Louis, Mo. Secy., W. F. Allen, 24 Park Pl., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 17-18. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 17-19. Annual convention at Boston, Mass. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 2-3. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 5-6. Annual meeting at New York City. Secy., W. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 6-9. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 7-9. Annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 12-14. Annual convention at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

NATIONAL ASSOCIATION OF CEMENT USERS.
Dec. 12-23. Annual convention at New York City. President, Richard L. Humphrey, Harrison Bldg., Philadelphia.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at St. Paul, Minn. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

ENGINEERS' SOCIETY OF PENNSYLVANIA.—A lecture on "Telephone Train Dispatching" was given by Mr. G. K. Heyer at the regular monthly meeting of Oct. 10 at Harrisburg, Pa.

AMERICAN ECONOMIC ASSOCIATION.—The annual meeting will be held at St. Louis, Mo., Dec. 27-30. Among the subjects to be discussed are canals and waterways, and railway rates. The secretary is Mr. T. N. Carver, Cambridge, Mass.

ENGINEERS' CLUB OF ST. LOUIS.—At the regular meeting held Oct. 5, Mr. J. W. Woermann, Assistant Engineer, Western Division, U. S. A., presented a paper, entitled "The Deep Waterway: St. Louis to Cairo." This paper gave a review of seven plans which have been suggested for securing a 14-ft. depth of channel in the Mississippi River.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The season of 1910-11 will be opened by the 252nd meeting at the United Engineering Societies' Building, 33 West 39th St., New York City, on Friday, Oct. 14, 1910, at 8 p. m. The paper of the evening will be "Potential Strength in Dielectrics," by Mr. H. S. Osborne, of the American Telephone & Telegraph Co., and Prof. Harold Pender, of the Massachusetts Institute of Technology.

A public meeting will be held in the United Engineering Societies' Building at 8 p. m., Oct. 17. Members of all engineering societies are invited to attend and participate. The subject for discussion is "Rapid Transit Requirements of Greater New York." The subject will first be presented in an informal way by Mr. F. J. Sprague, Past-President of the American Institute of Electrical Engineers and Chairman of its Railway Committee. His paper will cover the general facts pertaining to routes, construction and equipment of existing and proposed lines.